NOVEMBER, 1960
Vol. 14, No. 11

# FT food technology

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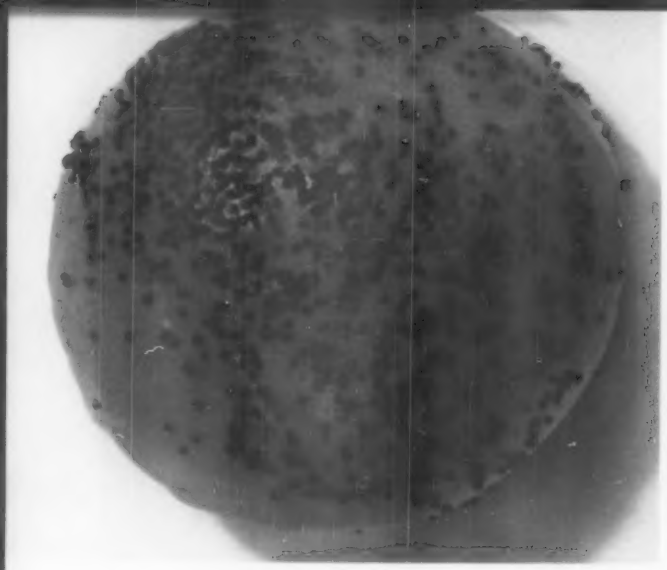

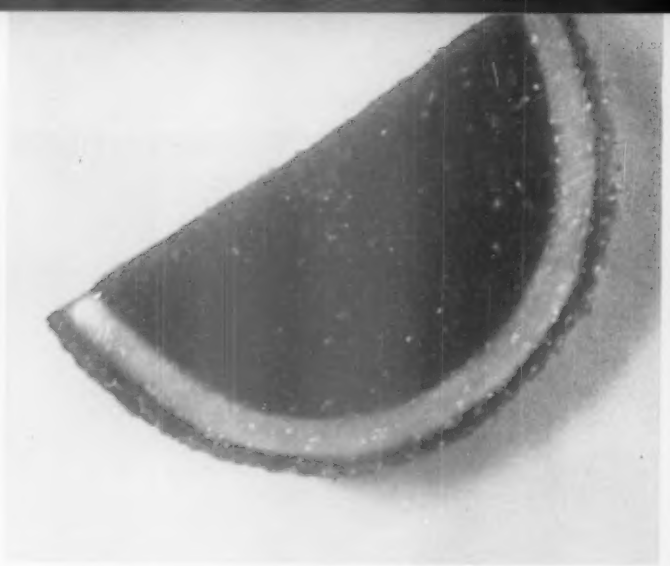

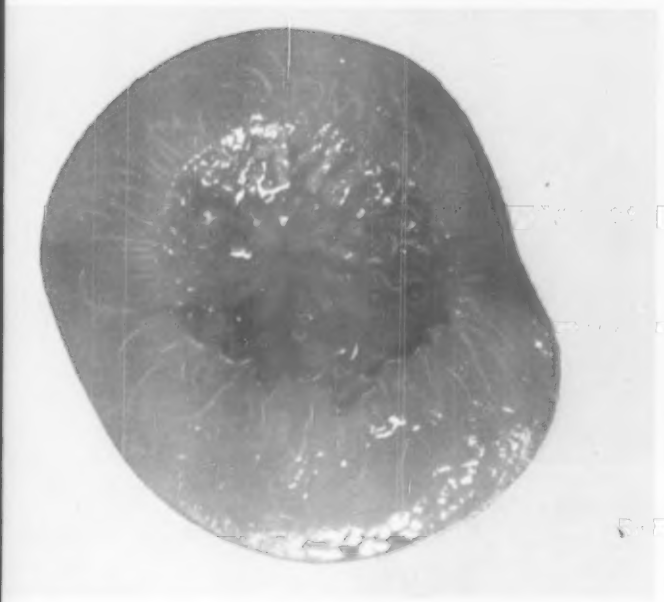

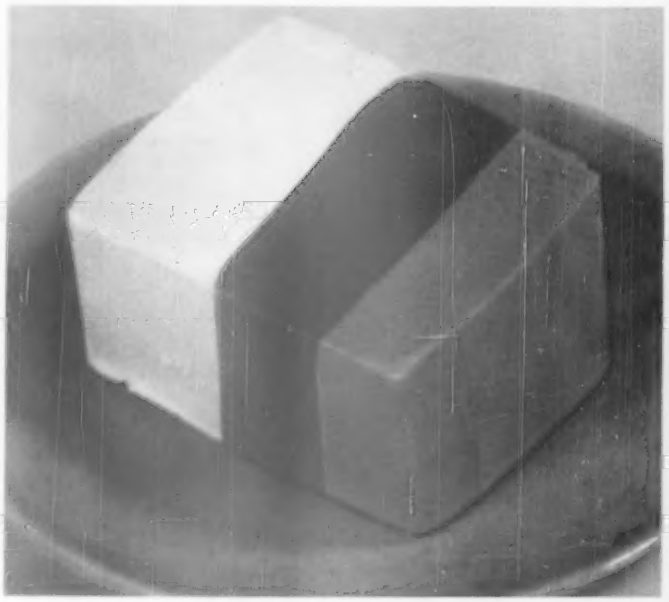

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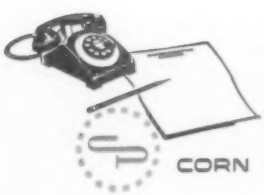

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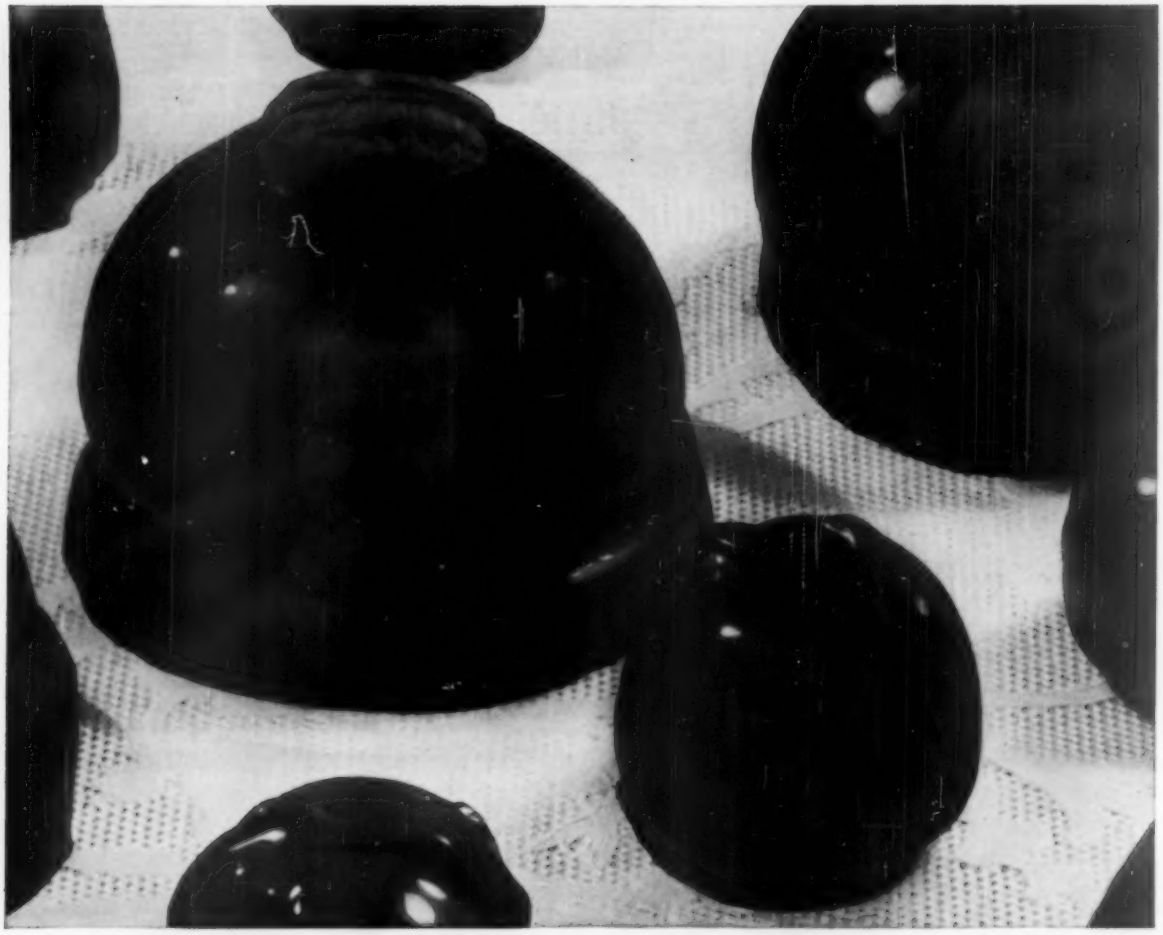

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Chicago 3, Illinois

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**Subscription Rates:** For members the cost of subscription is included in the annual dues. Non-members: Domestic, U.S. Territories, Canada and Mexico, $11.00 per year; Central and South America, $12.00 per year plus $1.00 postage; all other countries, $12.00 per year plus $2.00 postage. Single and back copies: domestic, $1.50; foreign, $1.75. Subscriptions are entered on a calendar year basis only. In the event a subscriber cancels, no refund will be made.

**Publication Office**
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Address to the Publication Office all requests for non-member subscriptions, back volumes, single copies (costs are listed above). Authors desiring reprints should address orders to this office; rates are printed on the order blank. (Requests for a single reprint of a published paper should be addressed to the author.)

FOOD TECHNOLOGY is published by the Institute of Food Technologists and printed by The Garrard Press, Champaign, Illinois, U. S. A.



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Mailing Permit: Entered as second-class matter, Feb. 25, 1947, at the Post Office at Champaign, Illinois, under the Act of August 24, 1912.



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# FT food technology

**NOVEMBER, 1960**
**Volume 14, Number 11**

PUBLISHED MONTHLY BY THE INSTITUTE OF FOOD TECHNOLOGISTS


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IN THIS ISSUE—

# TECHNICAL ARTICLES IN BRIEF

**The industrial way.** Arnold H. Johnson.

The recipient of the Babcock-Hart Award of the Nutrition Foundation, Inc. presents the efforts that have been made to impart keeping quality to milk products, "a line of investigation centuries old and still in progress." The essay articulates the major developments that began with the leads furnished by Appert and, later on, Pasteur, and have continued down the years. Radiation, freezing, the use of additives, and the efforts to achieve extended keeping quality by drying are passed in review. (See page 541).

*Effect of storage temperature* — *Viability of a yeast in orange concentrate*

**The viability of a yeast in high density orange concentrates stored at various temperatures.** Robert L. Kitchel and Martin W. Miller.

An osmophilic yeast *(Torulopsis magnoliae)* was isolated from 65° Brix concentrated orange juice and tested for its ability to ferment high density concentrates at various temperatures of storage. The yeast fermented all concentrates employed when stored at 60° and 80° F for 30 days. It also demonstrated significant growth in 60° Brix orange concentrate stored at 40° F for 90 days. Common commercial practice has considered 40° F storage sufficiently low to protect 65° Brix orange concentrate against spoilage. However, the data in this paper show that if orange juice concentrate becomes inoculated with this yeast, lower temperatures are necessary for product protection. (See page 547).

*Physical measurement* — *Salt diffusion into pork muscle*

**Curing of ham: A study of sodium chloride accumulation. II. Combined effects of time, solution concentration and**

---

# *Call for Nominations*—Food Technology Achievement Award

The IFT Food Technology Achievement Award is given annually to recognize and honor an outstanding food process and/or product, which represents a significant advance in the application of Food Technology to food production, and which has been successfully applied in actual commercial operation for at least six months but not over four (4) years prior to the date of calling for nominations. Insofar as possible, this Award shall be personalized by public recognition of the individuals(s) responsible for the achievement.

The Award will include the following: to the Company or Institution, a bronze Plaque. To the individual(s) judged to have made major contributions to the achievement, either through basic research or development, public recognition at the time of the presentation of the Award, and an engrossed Plaque.

Nominations for this Award may be made by any member of the Institute of Food Technologists. Each member of the Institute is urged to give serious consideration to the nomination of a product or process, not necessarily one in which your company is concerned. Each nomination must be in letter form and include the following:

A. Name of Company or Institution.
B. Name of Product and/or Process.
C. Description of Product or Process.
D. Statement of reason for considering this a meritorious achievement.
E. Statement listing individuals chiefly responsible for the achievement and their individual contributions.
F. Statement indicating the time and extent of commercial utilization.

NOMINATIONS MUST NOT EXCEED THREE, SINGLE-SPACED, TYPEWRITTEN PAGES.
Nominations should be sent, **postmarked no later than December 1st, to:**

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**November Cover.** Recipients of 1960-61 IFT administered fellowships and scholarships are recognized with a place on this month's cover. In the order depicted, they are: **General Foods Fund Fellowship:** William P. Ferren, Rutgers, The State University (renewal); T. E. Hartung, Purdue University; Allen T. Phillips, Louisiana State University. **Samuel Cate Prescott Fellowship:** Kenneth W. Lebermann, University of Illinois. **Florasynth Fellowship:** Steven R. Tannenbaum, Massachusetts Institute of Technology. **Gerber IFT Undergraduate Awards:** Ronald L. Ellerbeck, University of Illinois (renewal); John C. Bruhn, Michigan State University; John W. Galbreath, University of Georgia; Lynn Williams Higgins, University of California, Davis; Tony J. Sinskey, University of Illinois; Susan W. Spring, Ohio State University. **Alexander E. Katz Scholarship:** Maynard R. Johnson, Massachusetts Institute of Technology (renewal). **Dodge & Olcott Scholarship:** Theodore P. Labuza, Massachusetts Institute of Technology.

**solution volume.** H. E. Wistreich, R. E. Morse, and L. J. Kenyon.

In an effort to define the mechanisms involved in permeation, the effects of time, solution volume, and solution concentration on sodium chloride diffusion into pork muscle were studied. Accumulation of sodium chloride varied linearly with solution concentration and volume. The accumulation value-time relationship was logarithmic. An equation correlating the above factors was derived. (See page 549).

*Biochemical analysis* — *Changes in sterilized food during low temperature storage*

**Low temperature handling of sterilized foods. V. Biochemical changes in storage.** Aaron L. Brody, Karakian Bedrosian, and C. Olin Ball.

Results of this study clearly demonstrate that HTST processing methods can give a product which is equivalent or superior to conventionally canned product with respect to components investigated, and that products processed by either method are materially benefited by storage temperatures below 50° F. There was no evidence to the effect that HTST processed products, having an initially higher concentration of reactants deteriorated faster than similar conventionally processed canned products. (See page 552).

*Study of flow and heat transfer* — *Evaporation of fruit purees for concentrates*

**Viscometric behavior in relation to evaporation of fruit purees.** John C. Harper.

The performance of a wiped film evaporator in concentrating apricot, peach, and pear purees was investigated and the viscosity characteristics of the products established. It was shown that the viscosity behavior was well represented by the equation

$$\tau = K\gamma^n$$

Over-all heat transfer coefficients correlated well with values of K, and performance was found to be much better for non-Newtonian fluids than for Newtonians of equivalent consistency. (See page 557).

*Evaluation of instruments* — *Firm-o-meter, McCollum, Asco*

**Evaluation of instruments to measure firmness of tomatoes.** A. W. Garrett, N. W. Desrosier, G. D. Kuhn, and M. L. Fields.

In a study of the Firm-o-meter, the McCollum, and the Asco Firmness meters, data indicated that the Asco Firmness Meter was measuring firmness in the same manner as the Firm-o-meter. It was also found that the Asco Firmness Meter was measuring firmness in a manner similar to that determined by compressing the fruit in the hand. Flesh firmness of tomatoes as measured by the McCollum Firmness Meter was found to be correlated with firmness as measured by the Asco instrument. It appears that the Asco Firmness Meter would be a valuable tool in the breeding program for fresh tomatoes as well as in a quality control program with fresh tomatoes. The McCollum Firmness Meter can be used as a tool in the selection of

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firm fleshed tomato varieties, but due to its characteristics, it could not be very handily used in a quality control program. (See page 562).

*Microscopic examination* *Sausage emulsions*

**Emulsion formation in finely comminuted sausage.** Leo J. Hansen.

A dispersion of fat globules is formed within the protein slurry during chopping of finely comminuted sausage. The comparatively soft fat is broken up early in the comminution process but the globule size is reduced as chopping is continued. Muscle fibers of a stronger structure than fat, constitute the component which determines the total chopping required. Fragments of tough connective tissue formed by preliminary grinding appear to remain unchanged during chopping of sausage emulsions. Total chopping time must be sufficient to form a protein matrix enclosing the dispersed fat globules. Salt soluble proteins, myosin and actomyosin, appear to concentrate at the fat globule surfaces and form a stabilizing membrane. If excessive temperature rise occurs during chopping, the protein matrix may be partially denatured and broken giving rise to an unprotected fat dispersion. This permits fat separation during smoking and cooking. (See page 565).

*Enzymatic browning* *Peaches*

**Characteristics of browning enzymes in Fay Elberta freestone peaches.** Philip Reyes and B. S. Luh.

In a study of enzymatic browning, the characteristics and properties of polyphenolase and peroxidase from Fay Elberta peaches were investigated. The determination of optimum pH, Michaelis constant, and substrate specificity, as well as a study of chemical inhibition of enzyme activity, were made. A pH optimum of 4.6 to 4.8 in citrate-phosphate buffer, with guaiacol as substrate, was found for peroxidase. In the same buffer, polyphenolase with catechol as substrate, exhibited a pH optimum of 5.9 to 6.3. Michaelis constants of 0.12 M catechol and 0.010 M guaiacol are reported for polyphenolase and peroxidase, respectively. Both enzymes act primarily on the orthodihydroxy configuration. The paradihydroxy structure was also oxidized by both enzymes, but at a slower rate. Neither enzyme exhibited significant activity with the monohydroxy and metadihydroxy compounds as substrates. Sodium diethyldithiocarbamate inhibited the activity of both polyphenolase and peroxidase. In contrast, 1-penyl-2-thiourea inhibited peroxidase less effectively than polyphenolase. Phloroglucinol, in the concentrations used, inhibited peroxidase more effectively than polyphenolase. L-Ascorbic and D-isoascorbic acids were found to be equally effective as antioxidants. (See page 570).

*Statistical procedure* *For product comparison problems*

**A rapid method for determining significance of differences from rank sums.** Amihud Kramer.

This procedure is an expansion of one previously reported by the author. It is especially suitable where actual values are not meaningful—for example, in evaluations of sensory data when, on occasion, it may be more convenient to rank series of samples in order of preference or difference. The method is based on the expansion of the multi-

nomial distribution, using the treatment (t) designations as terms of the multinomial, and number of replications (r) as the power. The general expression is: $(t_1 + t_2 \ldots + t_n)^r$. (See page 576).

*Measuring tenderness* *Analysis of the meat grinder method*

**Variations and their causes in the measurement of beef tenderness by the electric meat grinder method.** C. M. Schoman, Jr., J. Bell, and C. Olin Ball.

Of the mechanical methods of measuring meat tenderness the best known are those associated with the Warner-Bratzler Shear, Penetrometer, Christel Texturemeter, the orifice, and the electric meat grinder. This study was conducted to investigate the causes of variations in the meat grinder method. The principal causes were found to be due to changes in the motor temperature, fluctuations of line voltage, and the variable friction of the rotating grinder elements. (See page 581).

*Antibiotic* *CTC concentrations required to inhibit bacterial growth*

**In vivo effects of chlortetracycline on bacteria indigenous to Gulf shrimp and oysters.** Arthur F. Novak, Ernest A. Fieger, and Keith A. Stolzle.

Employment of washes and dips of 5 to 20 ppm CTC have been reported to extend the ice storage life of Gulf oysters and shrimp for a period of 3 to 5 days, and the results reported here show that these concentrations of CTC inhibit growth of most bacteria indigenous to these shellfish for a similar period of time when tested in vitro. (See page 585).

*Gas chromatography and use of trained panel* *Bartlett pear flavor*

**Volatiles contributing to the flavor of Bartlett pears.** W. G. Jennings, S. Leonard, and Rose Marie Pangborn.

By processing fresh, ripe pears in a specially designed enclosed system, aqueous essences with the typical desirable aroma of Bartlett pears were recovered. Extracts of these were fractionated by gas chromatography to some 32 fractions. Results obtained with a trained panel indicate that five of these contributed significantly to the desirable pear aroma, and perhaps four possessed undesirable aromas. There were indications that copper or copper alloys can cause flavor degradation. Results permitted the gas chromatographic curve to be interpreted as a "flavor spectrum" and methods for accurately measuring the flavor content of pilot batches of fruit were suggested. Because essence fortification markedly improves conventional pear purees, processing of cull pears for essence recovery might prove economically feasible. (See page 587).

*Cleaning enclosed systems* *Effect of pressure*

**Effect of pressure on circulation cleaning.** Walter G. Jennings.

By use of a technique employing radioactive soils, it is shown that the rate of soil removal by circulation clean-


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ing is greater at lower pressures, and that the effect is linear. Thus, the cleaning efficiency of a circulation system can be increased merely by positioning the recirculating pump to pull, not push, the deterging medium through the area to be cleaned. The probable effects of higher solution temperatures and foaming detergents on reduced pressure cleaning is discussed. (See page 591).

*Fouling* *Heat exchanger tubes*

**Fouling inside heat exchanger tubes.** A. I. Morgan, Jr., and R. A. Carlson.

Various conclusions relative to fouling and heat exchanger design can be drawn. No considerable steam pressure can be used. Therefore ample tube area must be provided for any rated performance. Thermally saturated feed must be provided at the entrance to an efficient evaporator so that boiling occurs throughout the tubes, which means that ample preheaters must be supplied. No high vapor fraction can be allowed inside an exchanger tube. An evaporator must include means of removing vapor, such as multiple effects or recirculation. Viscosity should be kept at a minimum. Heat exchange should be to a liquid of as low solids content and as high temperature as possible. (See page 594).

*Measuring and classifying color* *Roast color of coffee*

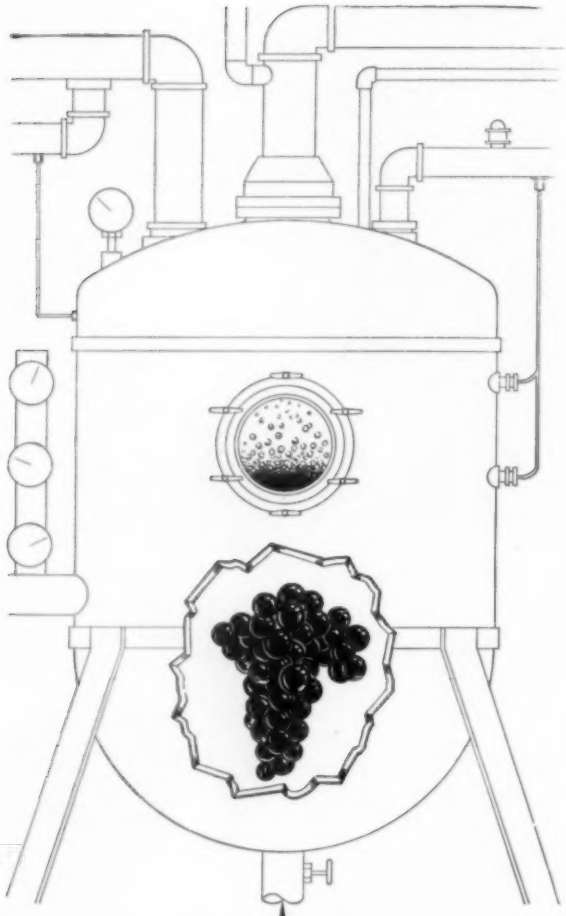
**Roasted coffee. Color measurement and classification.** Ernest E. Lockhart.

This paper describes a simple, rapid, and precise method for measuring the color of roasted coffee, provides a graded list of names applicable to colors of roasted coffee, and shows the association between the two. Numbers derived from measurement have been correlated with an attribute-intensity scale which provides uniform terminology as a replacement for the wide variety of terminologies now used by industry. A study of commercial retail roasts of coffee revealed a sharp differentiation between normal and espresso-type roasts. Regional differences in the U. S. A. are not pronounced but Midwestern and Western coffees appear to be somewhat lighter than Eastern coffees. (See page 597).

*Food economics* *Dehydrated-to-fresh ratio (onions)*

**Investigation of equivalent weights of dehydrated vegetables in comparison to their fresh conventional counterparts. I. Dehydrated sliced onions.** H. R. Ignall.

The equivalent weight of a dehydrated vegetable compared to its fresh, conventional counterpart must be known not only for cooking purposes but also as a basis for all logistical calculations. Where use of the vegetable is extensive, as in large group feeding programs, the accuracy of the ratio assumes vital importance. Such comparisons as space-savings, weight-savings, costs, and procurement requirements, among many others, are dependent upon this figure. For logistical purposes, an average equivalent weight ratio of 1:5.38 for raw, peeled onions and 1:5.98 for raw, unpeeled onions was determined by means of a frequency of use table. (See page 601).



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# CALL FOR NOMINATIONS

## The Babcock-Hart Award

Any member of the Institute of Food Technologists may submit a nomination for the 1961 Babcock-Hart Award between now and the January 1, 1961 deadline.

**Nominations must be made on the prescribed nomination form which may be obtained from the Executive Secretary, in order to be considered.**

Donor of the $1,000.00 and engrossed plaque accompanying the Award is the Nutrition Foundation. Purpose of the Award is: "To honor a person who has distinguished himself or herself by contributions to Food Technology which have resulted in improved public health through some aspect of nutrition or more nutritious food."

A nominee, to be eligible, must have made a technological development, or a scientific contribution leading directly to a technological development, which favorably affects the nutritional well-being of the public. **Contributions in clinical nutrition and fundamental scientific studies in nutrition cannot be considered as qualifying according to conditions established by the Donor.**

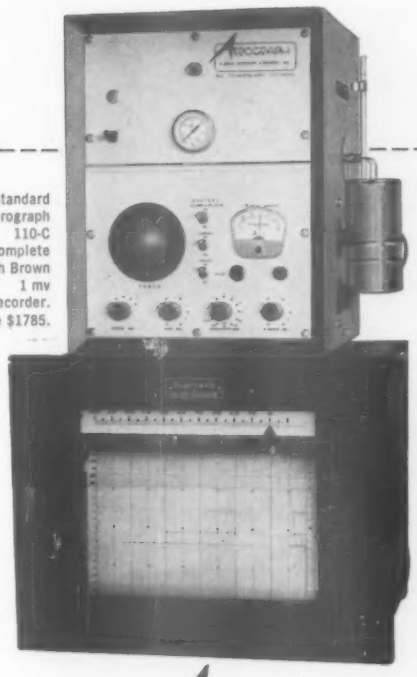
## The Nicholas Appert Award

Any member of the Institute of Food Technologists may submit a nomination for the 1961 Nicholas Appert Award between now and the January 1, 1961 deadline.

**Nominations must be made on the prescribed nomination form which may be obtained from the Executive Secretary, in order to be considered.**

Donor of the $1,000.00 honorarium accompanying the Award is the Institute of Food Technologists. The Award, originated by the Chicago Section, also includes a Bronze Medal which is donated by that Section. Purpose of the Award is: "To honor a person for pre-eminence in and contributions to the field of Food Technology."

Qualifying criterion for a nominee includes merely the fact that the nominator consider the individual so pre-eminent in the field of Food Technology that he or she should be acclaimed for contributions thereto. This precludes consideration of personality or other characteristics outside the field of contributions to Food Technology, as these factors may not be considered by the Awards Jury in making the selection.

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DEPT. 45

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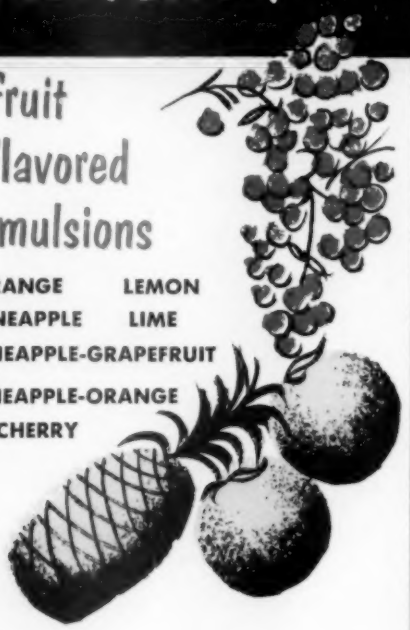

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# Deadline for Abstracts for Annual Meeting, 1961 Changed to March 15

Abstracts for papers to be presented at the Twenty-first Annual Meeting of the Institute of Food Technologists (New York, May 7-11, 1961) will be due on March 15, 1961, instead of on January 1 as previously required. The change to March 15 has been made in the interest of giving authors an opportunity to progress their work to the point where an abstract will reflect the resulting paper more faithfully than has sometimes been possible in the past.

Annual Meeting abstracts should be sent to the chairman of the session to which they pertain prior to March 15. Session chairmen were announced in the September and October issues of FOOD TECHNOLOGY.

## Research Fellowship Available at University of Alberta

A $2,000 to $3,000 research fellowship in dairy technology has been announced by the Department of Dairy Science, University of Alberta, Edmonton, Canada. It will be awarded for the purpose of furthering a study of the mechanical destabilization of the milk fat globule. The fellowship, tenable immediately, will be for one year, and subject to renewal for two additional years. Annual value of the award will range between $2,000 and $3,000, depending upon the qualifications of the applicant. To qualify, one should be a graduate of a university of recognized standing, preferably with qualifications in dairy or food technology.

Interested individuals should submit at once a letter of application, enclosing transcripts of university records and two letters of recommendation, to: Head of the Department of Dairy Science, University of Alberta, Edmonton, Alberta, Canada.

## New Position Open at Clemson College

A new position of Associate Professor of Food Technology has become available on the staff of the Department of Food Technology and Human Nutrition, Clemson College, South Carolina. Duties entailed will include both research and teaching. Prerequisite for consideration includes Ph.D. level training in food technology.

Those interested are invited to write: Head, Department of Food Technology, Clemson College, Clemson, South Carolina.

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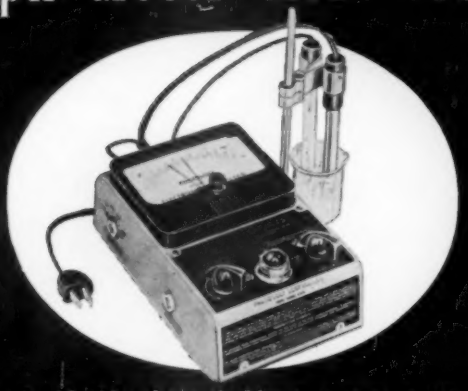

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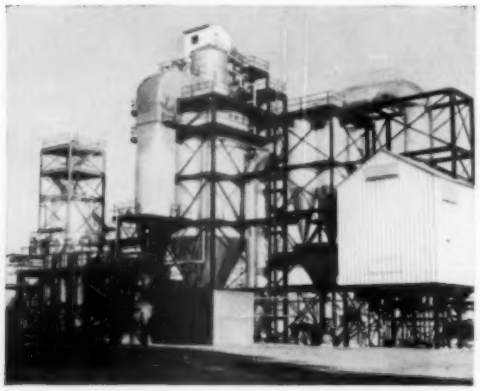

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# IFT News

## W. NEW YORK

An all-day meeting of the Western New York Section was held Thursday, October 6, 1960, at Jordan Hall, New York State Agricultural Experiment Station, Geneva, New York. The Program consisted of an address by Dr. Donald W. Barton, Director of the Experiment Station at Geneva, N. Y., a tour of the new Food Research Building, a luncheon speech by Dr. David B. Hand on "Areas for Expanded Research in the Department of Food Science and Technology," and talks by Dr. J. F. Perkins, Flavor Division, Firmenich, Inc., New York City ("Synthetic Flavors"); by Dr. C. Q. Lipscomb, Food and Drug Administration, Buffalo, New York, and by Mr. N. D. Pintauro, Jell-O Division Laboratories, General Foods Corp., Tarrytown, New York, on "Nutritional Modification of Processed Foods."

## BLUEGRASS

Dr. I. J. Hutchings, President of the Institute of Food Technologists, addressed the Bluegrass Regional Section on "Present Trends and Predicted Developments Involving Food Additives," at a dinner meeting attended by nearly four dozen people on Sept. 13. He emphasized the serious problems faced by food technologists in insuring that ingredients used comply with the law as written. He challenged his hearers to prepare for the possible alternatives that may occur March 1, 1961: Probable further extension to be provided by yet to be taken Congressional action or the possible elimination of many important ingredients necessitating subsequent changes in formulae while awaiting the results of scientific work, tedious and protracted, to establish the individual safety of each item.

**Appear on WHAS.** The following morning Doctor Hutchings and Dr. William J. Shannon, chairman of the Bluegrass Regional Section, were interviewed by Phyllis Knight over her popular program, "Small Talk," beamed at homemakers by Louisville's radio station WHAS. They had an opportunity to answer questions about food and food technologists and the work that is done to insure a safe and nutritious food supply.

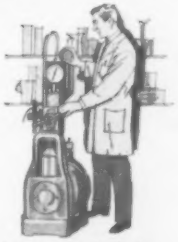
**Bluegrass membership diversified.** Membership of the Bluegrass Regional Section includes several fac-

# GAULIN G.T.A.

## *Gaulin Technical Assistance*

GTA Bulletins

Technical Assistance



Laboratory Analysis

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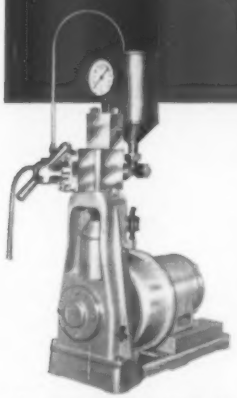

What's the best method to disperse, emulsify or blend? You can get the right answer on the most effective method with Gaulin Particle Control. Not only will Gaulin Homogenizers improve product uniformity, stop separation, accent taste, speed chemical reactions, but they will increase salability of products and cut costs.

Take advantage of Gaulin Technical Assistance, too. It provides free technical data, experienced advice and laboratory analysis. Write for GTA Bulletins . . . Homogenizers H-55, Sub-Micron Dispersers SMD-55, and Colloid Mills C-57.

**Try Particle Control In Your Plant . . . Rent a Gaulin Laboratory Homogenizer for Only $75.00 Per Month!**

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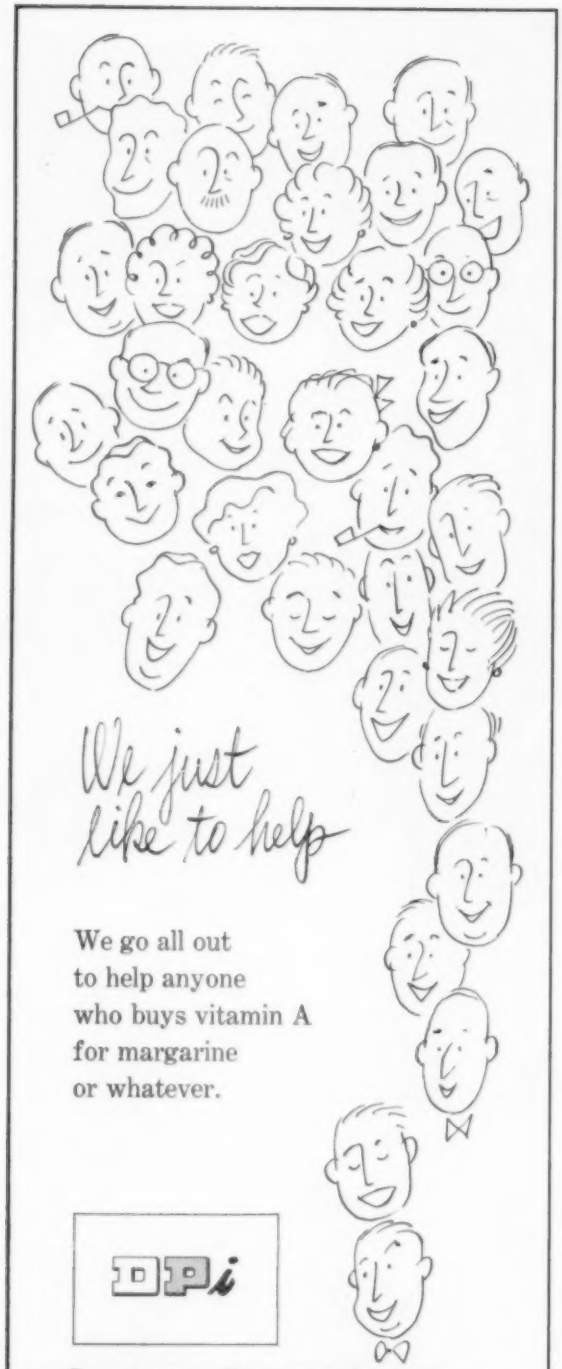
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ulty members of the University of Kentucky, Lexington, Ky., where courses are offered in dairy technology, horticulture, meat processing and animal husbandry, and home economics. Other members work in the more than two dozen branches of the food and beverage industry in the Louisville area. They are engaged in research, quality control, new product development, new packaging development, microbiology, equipment development, and process development. This diversity of professional interests within the general area of food science and technology will provide for this region a liaison of scientific and technical interests of great value to the food industries of the area and to the Bluegrass membership as well.

On Oct. 24 the Section heard Mr. E. B. Kennedy, director of economic development for the Commonwealth of Kentucky, on the "Economic Opportunities In, and the Future Of, the Food Industry in Kentucky"—a talk that gave us new perspectives on "food futures." Meetings also are planned for Nov. 10 and Dec. 6.

*—H. W. Putnam*

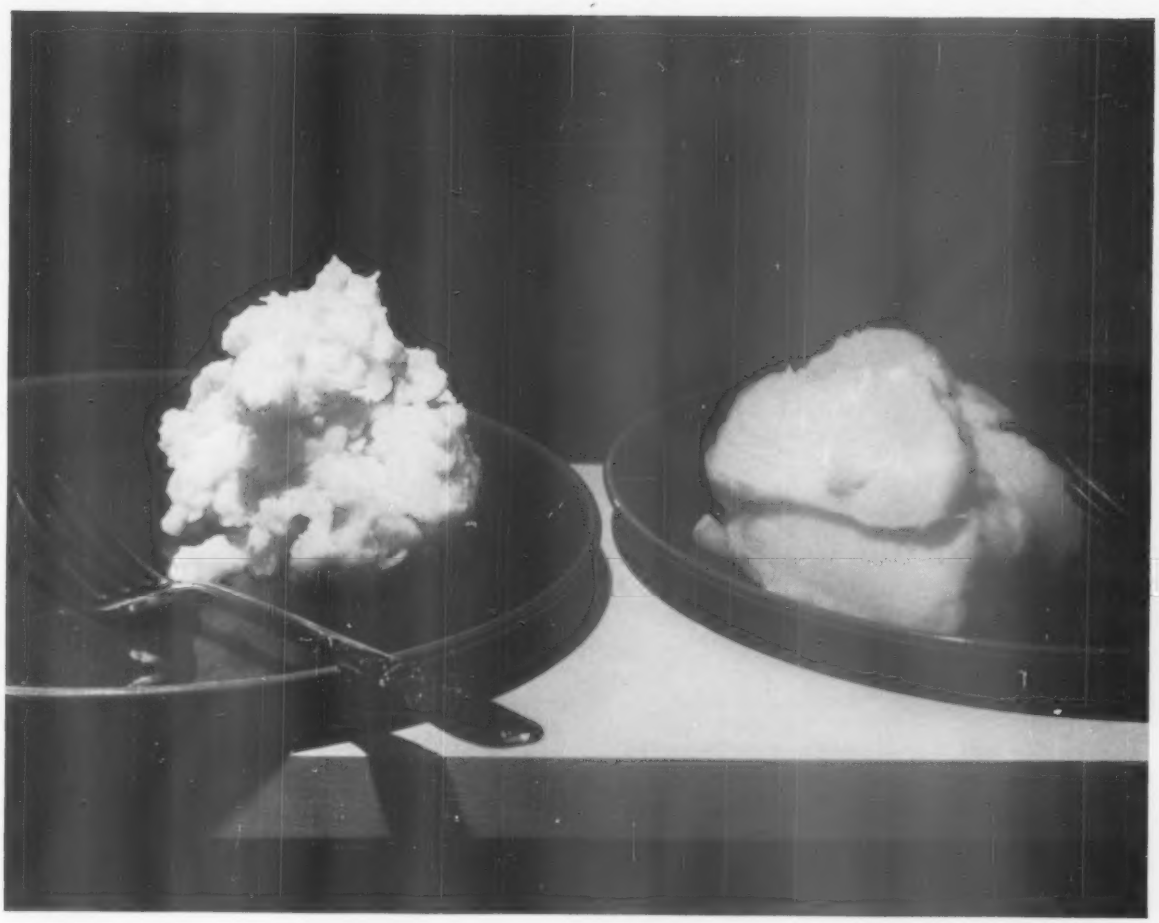
## FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

November 12-19 Fifth Pan-American Congress of Pharmacy and Biochemistry, Santiago, Chile. (For information address Senor José Pérez Molina, Secretary, Box 6084, Santiago, Chile).

November 13-14 Food Technology Short Course, University of Tennessee College of Agriculture, Knoxville, Tennessee. Technical Advances in Utilization and Disposal of Wastes will be discussed.

| | |
|---|---|
| 1961 | |
| February 2-3 | Statistical Quality Control and Instrumentation Workshop for the Food Industry (co-sponsored by Institute of Food Technologists, Western New York Section, and N.C.A.) Cornell University, Ithaca, New York. |
| February 28 and March 1 | Ninth Annual Dairy Engineering Conference, Michigan State University, East Lansing, Michigan. |
| **May 7-11** | **Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York** |
| May 15-18 | Fourth International Congress on Canned Foods, Berlin, Germany (for information, address M. Henri Cheftel, J. J. Carnaud & Forges de Basse Indre, 71 Avenue, Edouard Billancourt, Seine, France). |
| 1962 | |
| June 10-14 | **Twenty-second Annual Meeting of the Institute of Food Technologists, Fontainebleau Hotel, Eden Roc Hotel, Miami Beach, Florida** |
| 1963 | |
| May 19-23 | **Twenty-third Annual Meeting of the Institute of Food Technologists, Pantlind Hotel, Civic Auditorium, Grand Rapids, Michigan** |

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.



# After and before

Look at these two dishes of "instant" mashed potato. There is only one difference between them.

The one on the left contains ½ of 1% of *Myverol Distilled Monoglyceride, Type 18-00.** It looks, tastes, and feels to the palate like just-mashed potato. The one on the right, with no monoglyceride, is a sticky, pasty mess.

No one will be offended by this comparison because as far as we know there is very little, if any, instant mashed potato on the market that does *not* contain monoglyceride. Monoglyceride is one big reason why the instant mashed potato idea has been such a success.

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## EXPANSION NEWS

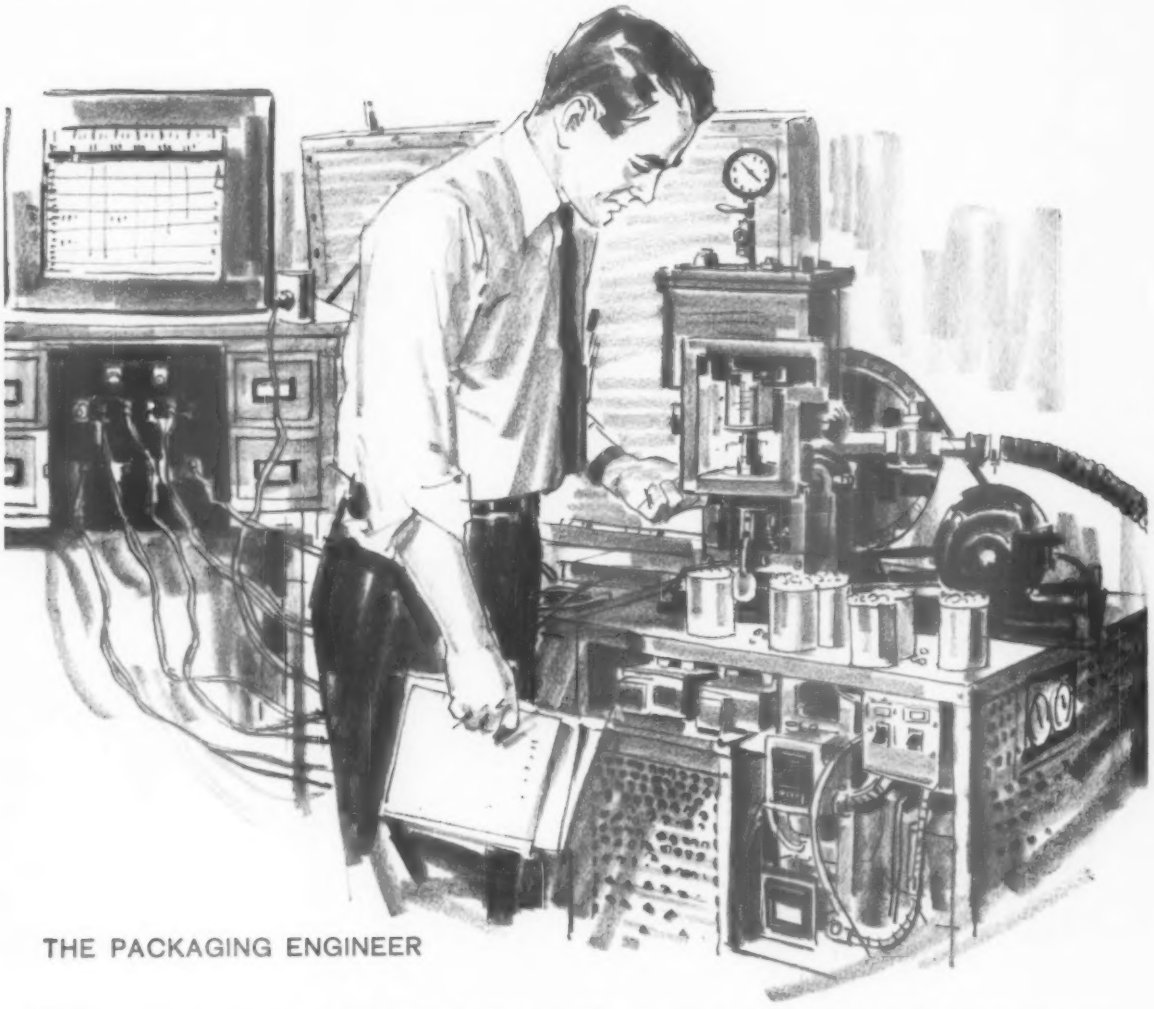
Pan-Am Foods, Inc. of Brownsville, Texas, Gulf Southern Corporation of Tampa, Florida, and Standard Fruit & Steamship Co., of New Orleans, announce formation of a new company, the Gulf American Corporation, 901 Twiggs Street, Tampa, Florida. **Mr. Michael L. Kuboviak**, past chairman of the Mohawk Valley Section and currently member of the executive committee of the Florida Section, assumes the position of Vice President, Research and Development, of the new food processing corporation. The firm will place emphasis on the development of new banana products, and in addition technical assistance will be available to processors and manufacturers desirous of adding banana products to their present lines.

A new company, the Hazleton-Nuclear Science Corporation, 4062 Fabian Way, Palo Alto, California, was formed September 26 in Palo Alto. It will be the West Coast affiliate of Hazleton Laboratories, Inc., of Falls Church, Virginia, and of Nuclear Science and Engineering Corporation of Pittsburgh, Pennsylvania, and will offer services which include: analytical chemistry; biochemistry; radio-chemistry, including low level radio-isotope assay; radio-biology; organic synthesis; toxicology; pharmacology; entomology; radio-isotope techniques, including industrial and agricultural trace application; decontamination and disposal techniques; and activation analysis. The organization will also provide consulting services in the food and drug, industrial hygiene, pesticide use and radiation control fields.

The merger of two Pacific Coast food processing companies, Nalley's, Inc. of Washington and IXL Food Company of California was announced recently. Both companies will retain their individual identities and brands, and will continue to operate with the same executives and personnel as they now have. Nalley's processes and distributes potato chips, pickles, canned meats, salad dressings and table syrups. IXL Food Company specializes in Spanish and Italian style canned foods, such as chili con carne, ravioli, tamales and lasagne.

Formation of a Food Division of United States Testing Company, Hoboken, New Jersey, to provide testing, research and development, analysis and product evaluation services for the food, beverage and confection industries has been announced by A. L. Brassell, President. Dr. Dean Foster has been appointed manager of the new division. Materials, products and processes under jurisdiction of the Food Division include: edible or potable agricultural or chemical raw materials; formulations; processing equipment and effects; packaging materials and designs; flavor, color and extending additives; processing and preserving agents; pesticides and antimicrobial agents, and all conditions affecting final quality and shelf life.

# CONTINENTAL SCIENTISTS WHO WORK FOR YOU



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# The Industrial Way*

**Arnold H. Johnson**
Babcock-Hart Award Recipient, 1960,
National Dairy Products Corporation,
Research and Development Division,
Glenview, Illinois

TO HAVE BEEN SELECTED to receive the Babcock-Hart Award this year is a great honor. I wish to express my appreciation to the Nutrition Foundation, which makes this award possible year by year, and to the Institute of Food Technologists, which administers it. As one contemplates the work of Babcock and of Hart, it is easy to sense why it was thought proper to identify their names with an award in food technology and in nutrition, recognizing as it strives to do, contributions to science or to technology that have been put into actual production on a large scale and that have actually resulted in an influence on better nutrition. It is an honor of special significance to me since I have worked in the same fields as did Babcock and Hart.

In my presentation today I might have chosen to discuss some continuity of their work. Babcock is probably best known for the development of the fat test which bears his name. His procedure remains little changed. This bespeaks the thoroughness with which the work was done. Certainly there have been many efforts to modify the test or to apply different principles for the determination of fat in milk, but no more acceptable method has been found "to determine rapidly the intrinsic value of milk." In commenting on this, in March of this year, Elvehjem *(2)* said "I am sure that Dr. Babcock would laugh if he knew we were still using fat to measure the nutritional value of milk in the light of more modern developments." The inclusion of protein as a possible factor in determining the value of milk was recognized long ago; in fact, by Hart himself. However, the Babcock method still remains the official method for determining the market value of milk. Incidentally, in the Netherlands both fat and protein are measured in assigning a value to milk.

I might also have chosen to discuss a continuity of some of Hart's work as it has developed in our laboratory and the laboratories of the industry. When Hart in 1902 returned to the New York Experiment Station in Geneva from his studies with Kossel in Heidelberg, he and Lucius Van Slyke began a study of the changes that take place in the milk proteins during the ripening or aging of chese. They established the relation between the solubilizing effects on casein, of enzymes originally present in the milk, of those elaborated by organisms used as cheese starters, and of those added with or as rennet. They identified the amino acid fractions as they changed in the ripening of the cheese. While Hart was engaged in amino acid fraction analysis for many years, he recognized early that protein breakdown products were not wholly responsible for cheese flavor, and that a substantial portion of the flavor was due to products resulting from fat hydrolysis. In spite of work on this problem, extending to the present, we have not come much beyond this point in elucidating the mechanism of cheese ripening.

I might also have chosen to discuss today food technology in a changing world, or more specifically, dairy technology in a changing world. However, Oser *(6)* on a similar occasion discussed the first subject in 1958, and Elvehjem *(2)* as recently as March of this year dealt with the latter.

I have therefore selected as the title for my remarks, "The Industrial Way." In selecting this title, I am influenced by having read a few years ago the book by Edith Hamilton entitled, *The Greek Way*. In this book the author develops the proposition that the Greeks brought into the world a new way of looking at things: a new way of looking at life itself.

Now I am not going to present a great new truth to you this afternoon. However, since the greater part of my career has been spent in dairy research, it is natural that I should select for discussion a problem of that industry. The perishable quality of milk vitally affects all phases of the industry. Successful development of a nonperishable sterile milk would have profound impact on the processing, distribution, marketing and consumption of milk. The ideal sterile product is generally conceived as one of maximum practical concentration for economy of packaging, storage and shipping which would maintain its quality in unrefrigerated storage and duplicate the taste of fresh market milk upon reconstitution. I will, therefore, present the efforts that have been made to impart keeping quality to milk products; a line of investigation, centuries old and still in progress, in which fortuitous circumstance, chance observation, dairy product processors, food technologists and scientists of the greatest skills have all had a part. My part has been the industrial way. I reconcile the importance of all these contributors to the developing technology by a quotation from Samuel Johnson, "The philosopher may be delighted with the extent of his views, the artificer with the readiness of his hands, but let the one remember that without mechanical performance, refined speculation is an empty dream and the other that without theoretical reasoning, dexterity is little more than brute instinct."

## IN RETROSPECT

Man observed centuries ago that the milk of mammals was good for himself and his children. We are all familiar with the story of Romulus and Remus and the she-wolf in the marshes of the Tiber. Recognizing that milk was a unique food, man has throughout history sought to have it available in some form at all

* The Babcock-Hart Award Address, delivered at the Twentieth Annual Meeting, San Francisco, California, May 17, 1960.

times. By trial and error, curd or cheese came to be the form in which milk could be stored in the warm countries because the milk soured and curdling took place before the cream could rise. In the northern countries, on the other hand, the cream separated by gravity and could be skimmed from the surface. Butter made from this cream accordingly became the form in which dairy products could be preserved. Thus, in Ireland, hogsheads of butter were buried in bogs for later use as needed for essential food, and also as a means of storing wealth.

The drying of milk to preserve it for later use is first mentioned in the writings of Marco Polo. On returning to Venice in 1295 he reported that the soldiers of Kublai Khan, the Mongol Emperor, carried with them in their wars a dried milk prepared by drying the liquid on hot stones in the sun. It is interesting that the invention of gunpowder in the middle of the 14th century gave considerable impetus to the advancement of dairying and the livestock industry. By the use of gunpowder, wild animals, especially those used for food were rapidly hunted down, and domestic animals had to be raised to supplement the depleted meat supply.

Coming now to relatively modern times, we find that Nicholas Appert, whom we honor each year, prepared dry milk in tablet form by drying a doughlike concentrate in a current of dry air. Appert was encouraged in his investigations on both concentrated and dried milk products by the prize of 12,000 francs offered by the French Government to anyone who could find a satisfactory method of preserving food. His experiments were begun in 1795 when France under Napoleon was fighting most of the other nations in Europe. Need for transportable food for the farflung French armies had prompted the government to offer this prize. The French Marine Department made use of milk produced by Appert's process in provisioning its warships. It is remarkable that Appert knowing nothing about bacteria came to the conclusion that food cooked and sealed and cooked again would remain in good condition. It remained for another Frenchman, Louis Pasteur, to repeat Appert's work about 50 years later, working first with wine and later with milk to demonstrate the mechanism of bacterial spoilage.

Following, and to some extent contemporary with the work of Appert and Pasteur, there was great activity on the part of inventors, perhaps we should call them food technologists of the day, to impart keeping quality to milk by some type of processing. By the end of the 19th century procedures had been developed for concentrating and drying milk. The most successful of these processes and the first to achieve acceptance as a product of industry, involved the addition of sugar to the concentrated milk product. Again, war played a leading part in the development of this product. Thus, sweetened condensed milk became the form of milk supplied to the Northern Army during the Civil War. Its success in a time of emergency established sweetened condensed milk as a regular product of industry. It required another war, the Spanish American, to establish the dependability of evaporated milk as a safe, sterile, transportable, concentrated milk. However, not until after World War I, in which this product supplied the need for milk to the armed forces of the United States and its allies, did a substantial industry develop. Thereafter, this product achieved world-wide use on a consumer basis.

In the meantime, progress on the drying of whole milk was far from satisfactory. Fleischmann *(3)*, an eminent German dairy scientist of his time, observing the poor keeping quality, the unpalatability, the insolubility, and the denatured condition of the protein of dried whole milk, and commenting on what he must have conceived as a crucial test, wrote "As a result of this failure, the question whether it is possible to produce a marketable product worthy of the name milk by dehydrating milk and reconstituting the resulting mass, is thus answered conclusively and for all time." This was the situation in the early 20th Century. I mention Fleischmann's work primarily to highlight the problems, some of which still exist, at least in part. The difficulties of converting whole milk to a satisfactory dried product soon caused efforts in drying milk to be directed primarily to skim milk and not until World War II did the situation change substantially. Then great effort was made by our own research group as well as others to develop procedures for producing a satisfactory whole milk powder. Thus, from 1939 to 1945, production of dried whole milk increased from 25 million pounds to about 217 million pounds per year, more than 800%. By 1959 production had fallen to about 97 million pounds.

But I am getting ahead of my story. Heated milk, soon to be called pasteurized milk, was practically unknown before the first years of the 20th century, unknown at least as far as the milk-consuming public was concerned. The heating of milk was considered a deceitful procedure as it delayed souring, a characteristic of fresh milk. Probably no subject outside of religion and politics has been the cause of more prolonged and bitter controversies than the proposed compulsory pasteurization of milk. Gradually, however, heated or pasteurized milk was offered to the public, first at special milk stations and then as a routine product. Thus, in New York, pasteurized milk was available at milk stations and dispensaries as early as 1889 but pasteurization did not become a commercial process until 1898. Chicago in 1908 became the first city to require compulsory pasteurization of all milk except that produced by tuberculin tested cows.

Thus, by the early years of the 20th century, certain inventions had been made and certain technologies were beginning to be applied that were to convert the relatively "cottage" industry of that day to the highly technical and specialized industry of the present. Chief among these developments were the invention of the cream separator by the Swedish engineer, DeLaval, in 1879, the imparting of keeping quality to milk by heat treatment resulting from the work of Pasteur in 1864, and the butter fat test as a method for rapidly assigning intrinsic value to milk announced by Babcock in 1890. In the years to follow,

many other scientific and technological developments have contributed to the growth of the dairy industry. From 1900 to the present, milk production itself practically doubled, that is, increased approximately from 63 billion to 125 billion pounds per year. Improved forages, improved feeding practices and improved breeding programs are in part responsible for the increased production as doubling in production occurred with less than 50% increase in number of milk cows. Other technological factors responsible for the growth of the industry are the proven value of milk as a superior source of food, convenient packaging, the development of mechanical refrigeration, rapid transportation from farm to processor and consumer, the adaptation of stainless steel equipment to the fabrication of dairy processing equipment, the development of homogenized milk, and the introduction of vitamin D into milk. These have been some of the more important developments. Each would make a fascinating story. In toto, they have operated to make dairying in its broadest sense our largest agricultural enterprise. In 1958 farmer income from dairying was 6.4 billion dollars and the consumer spent 16% of the food allowance for dairy products. In reviewing the nature of the dairy enterprise, Sheuring has stated that dairying has truly become "a business giant that exerts a great influence upon the economic, nutritional and political welfare of people all over the world." As I have said, milk production in 1958 amounted to 125 billion pounds which went into the numerous products of the industry but of which 48% was consumed as fluid milk.

It is no wonder then that saving the milk supply has been a concern of mankind for many centuries.

## IMPROVING KEEPING QUALITY

From the research scientist's point of view, the problem of improving keeping quality may be said to be "a many spendored thing." Many phenomena are operative, the effects of which vary depending on whether the dairy product is fluid milk, concentrated milk or dried milk. Bacterial action; enzyme action; fat oxidation per se or catalyzed by contaminants, such as, copper; protein-lactose interaction; calcium- or cation-protein interactions: heat effects; insolubilization of protein; viscosity changes and other biochemical and organoleptic changes not yet identified may be involved. Many of these reactions and the processing procedures bringing about organoleptic change have for years occupied the attention of our own laboratory as well as other dairy research laboratories.

Pasteurization as originally applied to milk had as its main purpose the improvement in keeping quality, quite apart from its later compulsory use to provide a safe food. Probably because control instrumentation was not available in the early 1900's, high-temperature short-time procedures were abandoned for long time procedures; for example, 143° F for 30 minutes. Retaining of the cream line and prevention of cooked flavor were also requirements for the acceptable pasteurization procedures. As equipment and instrumentation became available, there was a return to the high-temperature short-time procedures originally tried and now almost universally used especially in large plants. A usual procedure is to hold the milk for 17 seconds at 163° F. In Europe, a process known as Stassanization calls for heating the milk at 167° F for 15 to 16 seconds under slight pressure. This treatment under pressure prevents loss of carbon dioxide from the milk and is claimed to yield a milk retaining more completely its original properties.

It is apparent that milk may be subjected to many combinations of temperature and time to effect pasteurization or even sterilization. Such procedures bear such names as UHT (ultra high temperature) or VHT (very high temperature) treatment. In Switzerland, a process known as Uperization involves heating deaerated milk with jets of deaerated steam to bring the temperature to 303 to 320° F for 0.75 seconds, followed by aseptic canning.

In the United States, Stewart and coworkers *(8)* have described a process by which milk is deaerated, sterilized, cooled, oxygen added to react with the reducing substances formed by the sterilizing treatment and aseptically canned.

Maintaining keeping quality involves more than bacteriological stability. Thus, referring to pasteurized milk, milk of the highest sanitary quality appears most often to be plagued by development of oxidized flavor. The consumer usually designates this flavor as cardboard, the Germans as sandpaper flavor. Milks differ in their susceptibilty to the development of this flavor. In addition, the problem is seasonal. Since milk of the highest sanitary quality is often the most susceptible, it would appear that raw milks of higher bacterial count have their oxygen lowered by the action of bacteria, hence, oxidation of milk fat cannot occur.

It was found that very small amounts of copper in the milk catalyzed the development of the flavor. For this and for other reasons, different metals than copper and copper alloys were sought to be used in the fabrication of dairy equipment. When our laboratory was established in 1929, oxidized flavor and proper metals or alloys for dairy equipment were considered most pressing problems. Shortly, chromium-containing stainless steel became the alloy of choice. It was necessary for us to establish by animal feeding experiments that milk in contact with chromium-containing metals was safe, even though no chromium could be found dissolved in the milk.

Another development in which our laboratory played a leading part was that of homogenized milk. Fortuitously, homogenized milk is less susceptible to the development of oxidized flavor than the unhomogenized product. In fact, addition of homogenized milk to regular milk operates to prevent a certain type of oxidized flavor development in the blended product.

Homogenized milk, however, brought with it its own peculiar problems. Clarification must be accorded the product or leucocyte sedimentation would occur; pasteurization must be conducted immediately before or

after homogenization to prevent the action of lipolytic enzymes on the greatly increased fat interfaces with consequent development of rancidity; protection from exposure to sunlight must be provided in order not only to prevent development of sunlight flavor but also to prevent destruction of riboflavin. Processing procedures including packaging and distribution have largely solved these problems.

While Appert and Pasteur were the first to study the preservation of liquid foods by moderate heating, the value of heat for this purpose was known long before their time. Thus, Spallanzini almost a century earlier observed that boiling preserved meat extract. Boiling also preserves milk, sterilizes the product. The evaporated milk industry is based on such a process, that is, heating the concentrated milk in hermetically sealed cans to temperatures above boiling, e.g., 245° F for 15 minutes. In England about ten per cent of the fluid milk is sterilized by circulating the sealed bottles through boiling water or through chambers attaining the boiling temperature or higher. Milk processed in this manner exhibits the flavor generally designated as cooked. It was natural therefore to seek other means of treating milk to accomplish not only the effects of pasteurization, but in addition, those of sterilization while still retaining unimpaired the properties of the original milk. Various forms of energy have accordingly been applied in efforts to pasteurize or sterilize milk. In some cases, the new type of energy was investigated by itself, in others, the new form of energy plus heat was studied, with the thought that a heat treatment not sufficient to impair flavor would inactivate enzymes and the combined effects of the two treatments would yield the desired sterile product. Ball in 1955 *(1)* discussed the possibilities of such procedures as applied to foods in general and was not optimistic that any more satisfactory process would be found than heating.

**The Electropure process.** Among the first such procedure to be tried was the "Electropure" process in which the milk is passed between carbon electrodes connected with a source of low frequency electric current. Milk has poor electrical conductivity so that heat is produced on passage of the current between the electrodes. It was once thought that the electric current had some specific lethal effect on the bacteria. Now it is known that heat arising from the process is alone responsible for the bacterial destruction. The Electropure process enjoyed some success in this country and in Europe, and was no doubt the forerunner of the high-temperature short-time process development which has completely displaced it.

Subjecting milk to high pressures and then suddenly releasing the pressure has also been investigated as a possible method of sterilizing milk. Thus, when milk is put under pressures of 10,000 atmospheres and the pressure suddenly released by expanding the compressed milk into a vacuum, there is a substantial reduction in bacterial count. However, no combination of acceptable temperature and pressure manipulation has yet yielded a satisfactory sterile milk.

Another process that is being studied now is a combination of heat treatment and centrifugation with the thought that high speed centrifugation would remove types and numbers of bacteria so that a heat treatment comparable to pasteurization would yield a sterile or near sterile milk. Such a process will no doubt yield a product of lower bacterial count but the milk is not likely to be sterile.

**Ultrasonic energy.** Ultrasonic energy has also been applied to milk. By intensive irradiation continued for sufficient time, it is possible to sterilize milk by this procedure. Bacterial destruction appears to be due to two phenomena; ultrasonic energy converted into heat, and disintegration of bacterial cells by the treatment. Ultimate evaluation of this process awaits development in the industrial way. Incidentally, ultrasonic treatment also operates to homogenize the milk.

**The Hofius process.** Another procedure used in extending the keeping quality of milk is that known as the Hofius-Richter or Hofius process *(5)*. This process involves subjecting the milk to increased pressures of nitrogen or oxygen, particularly the latter, pressures between 2 and 10 atmospheres being used. By a combination of heat treatments and oxygen pressures, the keeping quality of milk may be significantly extended. This process has found application particularly in Germany, but again, a sterilized milk of beverage quality has not been forthcoming.

## IRRADIATION

In the course of the years, milk has been subjected to various types of irradiation. Ultraviolet irradiation, including mercury resonance irradiation, has been extensively studied and the wavelength that is most effective for destruction of bacteria established at 2600 Å. Because of the low penetrating power of ultraviolet in milk, it is necessary to expose the total mass on a thin surface or to accomplish the same result by creating turbulence in a long quartz tube in order to obtain bacterial destruction. It is also necessary to irradiate the milk in the absence of oxygen to prevent the formation of ozone which causes off-flavor development. An experimental plant making allowance for these factors has been constructed in Germany. Its efficency remains to be determined.

Milk has also been sterilized by x-ray treatment. However, even with high voltage equipment, the time required to sterilize is so considerable, that it is difficult to envisage this method of treatment as being practical.

Ionizing radiations have been studied extensively for their lethal effects on microorganisms. The late Doctor Proctor and his associates addressed themselves particularly to studying the effects of ionizing radiations on milk *(4)*, using intensities of gamma irradiation sufficient to yield a practically sterile milk. Milk was chosen for their studies because such irradiation resulted in the strongest and most undesirable off flavors that they had yet encountered. Accordingly, any progress that was made in studying this food could be applied with greater hope of success to other

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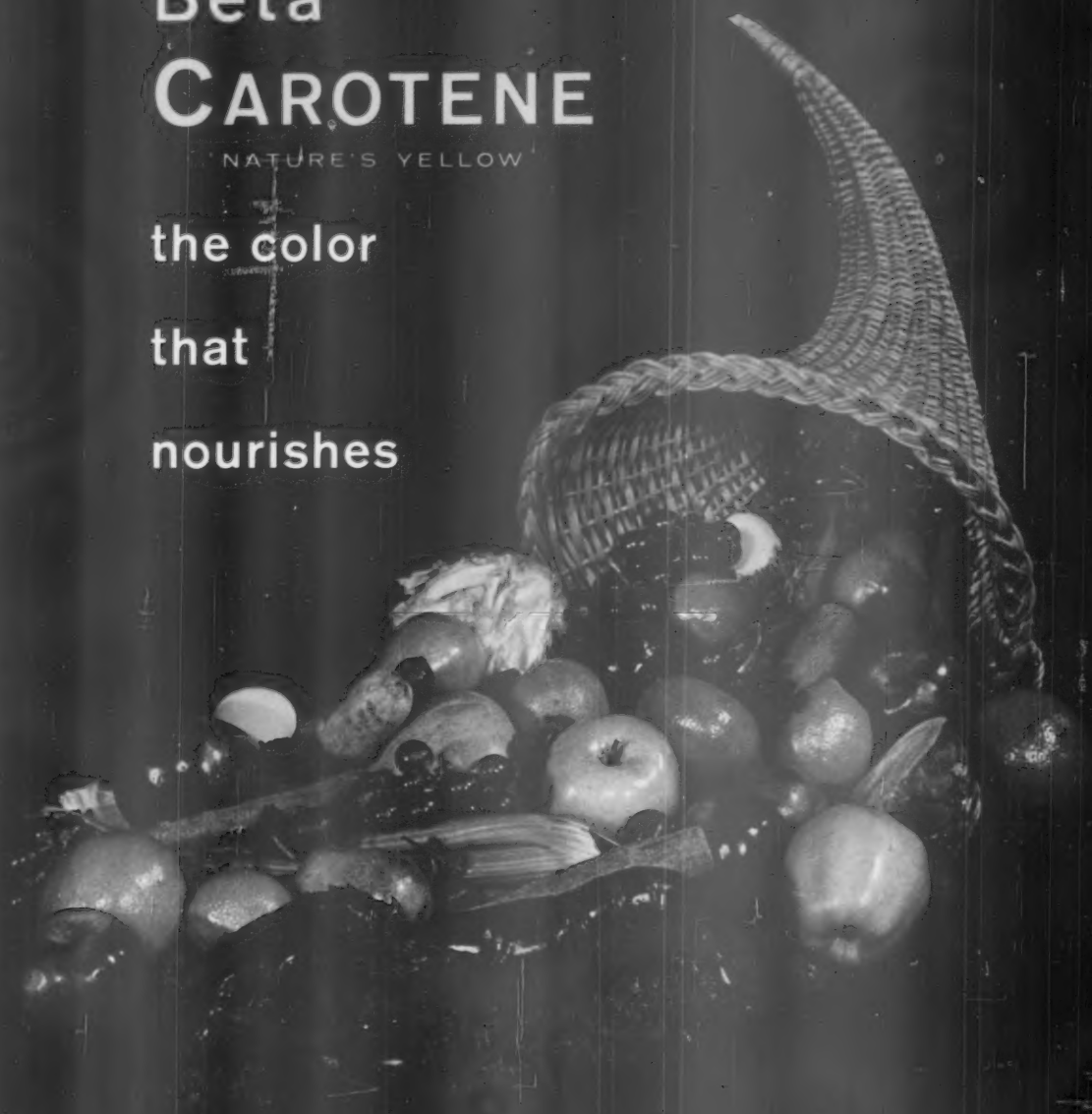

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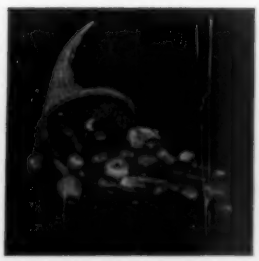

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foods. An irradiating procedure was developed which increased the volatility of the off-flavor complex or its precursors so that milk or milk concentrates could be sterilized by cold sterilization to yield a product free of detectable off flavors. This is a great step forward. It would appear that the work needs adaptation to the industrial way.

High velocity electrons or cathode rays, capable of destroying bacteria with high effectiveness have also been used in the irradiation of milk. However, side reactions take place which affect adversely the palatability of the product. Perhaps the same procedures used in working out similar problems in the ionizing radiation of milk would yield promising results when applied to cathode ray sterilized milk.

Radio frequency pasteurization has also been applied to milk. The mechanism here is actually resistance heating just as for the Electropure process, with the difference that the electrodes do not need to be in contact with the milk. Milk can be heated very rapidly to a given temperature by this process. It is not definitely known whether the bactericidal effect is due entirely to the heat generated or to the heat plus other effects. The process requires further exploitation to establish its practicability; again, if you please, the industrial way.

## FREEZING, USE OF ADDITIVES, AND OTHER EXPERIMENTAL APPROACHES

Microbiological deterioration of milk can of course be prevented by freezing. However, a number of other deteriorative changes take place in stored frozen milk. The most important are the development of an oxidized flavor and the denaturing of the protein. The first of these is evident by taste and the latter by unsightly flecks on the glass containing the milk. Development of oxidized flavor can be minimized by addition of ascorbic acid and a high heat treatment, denaturation of protein by addition of sodium citrate before freezing. Although milks modified in this way were investigated for use by the Navy, such products were never produced in substantial quantity.

It would be surprising indeed if "additives," and I pause on use of the word, had not been used in efforts to extend the keeping quality of milk. I will mention a few of the types of "additives" that have been considered. Subtilin was suggested as a possibility and other antibiotics have also been tried. The work, however, was primarily exploratory in character. Menadione, that is, vitamin K, was reported a few years ago to retard souring and to increase by 20% the keeping quality of the pasteurized milk when this material was fed to the cow. This result has not been confirmed. Hydrogen peroxide was added to milk in Italy just after the war and before adequate pasteurization facilities could be installed, the hydrogen peroxide ultimately disappearing due to action of milk catalase. Salt adjustment in evaporated milk is well known, phosphates and citrates being used to impart stability to the product during sterilization and subsequent storage. Some antioxidants have been tried and others will no doubt be sought to prevent oxidation changes in milk. For dried milk products, particularly dried whole milk, surface active materials may have a place in imparting dispersibility to the product.

I know that I have not mentioned, to say nothing of having described adequately, all the processes that have evolved in efforts to impart keeping quality to fluid milk. I do hope, however, that I have given you some idea of the scope of the effort.

From the standpoint of economy of transportation and distribution, it would be desirable, of course, to have sterilized milk in a more concentrated form so that the housewife could reconstitute it and obtain milk of beverage quality. Hence, evaporated milk since its invention by Gail Borden and its later acceptance as a consumer product, has been subjected to steady and sometimes intense experimentation, even as it is today. While significant improvement has been made, the product has still not achieved beverage quality. The main problem is to sterilize without imparting cooked flavor to the product.

Vigorous agitation of the milk in the can during sterilization certainly helps and so also does aseptic canning. Periodically, the Government sponsors a Milk Concentrates Meeting at which the best products of industry and research are evaluated. Progress was last reported in March of this year. The products demonstrated were not, I am sure, good enough to satisfy the American palate, accustomed as it is to fresh pasteurized milk.

The heated flavor of evaporated milk is attributed largely to the sterilizing step in the manufacturing process and not to the concentrating step. Freezing the pasteurized concentrated milk without sterilizing it, appeared, therefore, to be a promising procedure. I have already mentioned the problems encountered in the freezing of ordinary fluid milk. In frozen concentrated milk, difficulties with protein denaturation are accentuated. If the milk can be held frozen at −20° F., it will keep fairly well. At the freezing temperatures more generally available, i.e., 0 to +5, there results a protein denaturation, evident first by an increase in viscosity, followed by setting as a rigid gel and finally by irreversible denaturation giving the appearance of curds and whey. Onset of protein denaturation in the frozen milk was found to coincide with lactose crystallization. Removal of a portion of the lactose as by enzyme treatment increased the stability during frozen storage. This is the basis of a process which may find commercial exploitation.

Addition of small amounts of sucrose to the milk which affects lactose crystallization also operates to prevent protein denaturation. The limiting factor on the use of sucrose is the sweetness contributed by this sugar.

## DRIED WHOLE MILK

Finally, we come to a third way of imparting keeping quality to whole milk which is by drying. About 75 years ago, this was the great hope. Whole milk could be dried, but the keeping quality was so poor that production was practically abandoned. As has been said, not until World War II did production of

dried whole milk receive impetus. This was due to the need for a milk in its most stable as well as in its most concentrated and compact form for transportation to the far flung armed forces of our country. Some of you may have participated in the crash programs of that time. This work did much to bring whole milk powder to its present status. The most important developments were the high heat treatments accorded the milk before drying to develop natural antioxidants; the protection of the dried product from oxygen uptake before packaging; the practical elimination of metal contaminants in the milk, particularly copper; control of the moisture content of the dried milk within a specified range; and the nitrogen or gas packaging of the product with special procedures to remove oxygen. Drying the whole milk in a closed nitrogen system or by lyophilizing procedures yielded excellent products immediately after drying, but their storage stability was not appreciably better than products dried by improved processing and conventional drying procedures.

## A COMPLEX PROBLEM

And now we come to a phase of keeping quality which may be more difficult of solution than those already discussed. Thus, we may have a sterilized fluid milk, a sterilized concentrated milk, or whole milk powder which when fresh is remarkably good. At ordinary refrigerator temperatures these products retain their satisfactory organoleptic properties to varying degrees and for varying times. At room temperature, however, they soon lose the flavor qualities of beverage milk certainly before they reach the consumer in ordinary channels of distribution as non-refrigerated items. Thus, fluid milks, heat-sterilized sufficiently to have cooked flavor, are fairly stable in their organoleptic properties, due to antioxidant and perhaps other effects imparted by the heat treatment. On the other hand, milks heat-sterilized in such a manner as not to have cooked flavor or a minimum of it are subject to other deteriorative changes during room temperature storage. The seriousness and complexity of this problem is discussed by Ball, as already mentioned. The nature of these changes is not understood but is being sought in both academic and industry laboratories. Thus, basic studies are in progress on the physical and chemical constituents of milk; on how temperature, electrolyte concentration, specific cations and anions, and other factors affect these constituents; on possible interactions between protein, carbohydrate and lipid; and on moisture content in relation to organoleptic changes in products varying in moisture from that of fluid milk to relatively dry whole milk powder.

In view of the complexity then of imparting keeping quality to dairy products, it is no wonder that man has so long sought to accomplish this purpose and obviously the end is not yet. Work is being done in our own laboratories, the industrial way, to bring about this result in which basic findings and technological know-how are applied to the problem. I hasten to say that the problem has the attention not alone of my own segment of the industry but that of the whole industry including State, Federal and international research groups. At the present time, a process based on some manipulation of heating temperatures and times combined with aseptic canning, appears to have the most promise of success although a combination of a heatting plus some yet-to-be worked out procedure remains a possibility. The ultimate product must have organoleptic stability during reasonable storage and that phase of the objective is envisaged in the over-all solution of the problem.

In this discussion I have limited myself rather strictly to a consideration of keeping quality. I realize that there are other factors which will determine the acceptability of the product. A dried whole milk must, for example, be readily dispersible. In addition, the nutritional value of the final product must be substantially the same as that of the original milk by whatever processing is used. It is important that there be a continuity of research on the place of dairy products in the diet. Certainly one of the pressing problems of the day is to ascertain the facts concerning the significance of dairy products, butter fat in particular, in relation to certain types of cardiovascular difficulties and arthritis.

In concluding, I have sought to present to you something of the scope of the effort that has been expended to impart keeping quality to dairy products. I have tried to do this from the industrial point of view, the industrial way, if you please. Year by year, we make progress; and by "we" in this case, I mean the industry as a whole. I believe a sterilized milk of minimum heated flavor or a dried whole milk of satisfactory flavor will ultimately be produced. It then remains either to store them properly or to build in new factors so that original beverage quality will be retained over more flexible storage conditions.

## LITERATURE CITED

1. Ball, C. Olin. Food sterilization methods—the future. *Food Technol.*, **9**, 588 (1955).
2. Elvehjem, Conrad A. The dairy industry in a changing world. *J. Dairy Sci.*, **43**, 429 (1960).
3. Fleischmann, W. *Lehrbuch der Milch-wirtschaft.* (1908).
4. Goldblith, S. A., and Proctor, B. E. Radiation preservation of milk and milk products. I. Background and problems. *J. Dairy Sci.*, **39**, 374 (1956).
5. Hofius, Theodore. Preserving Foods. German Patents 613717, 696251.
6. Oser, Bernard L. The food industry in a changing world. *Food Technol.*, **12**, 493 (1958).
7. Sheuring, John J. The nature of the dairy enterprise. *J. Dairy Sci.*, **43**, 900 (1956).
8. Stewart, Aubrey P., Wilcox, Donald F., and Johnson, Roberta A. Process for Treating Fluid Dairy Products and Product Produced Thereby. United States Patent 2,788,283.

# The Viability of a Yeast in High Density Orange Concentrates Stored at Various Temperatures[a]

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(Manuscript received June 2, 1960)

MICROBIOLOGICAL SPOILAGE of citrus concentrates above 60° Brix is primarily limited to yeasts and molds. The high percentages of sugar and acid in citrus products inhibits the development of most bacteria. However, under certain conditions some of the lactic acid bacteria may be involved *(4, 14)*.

The occurrence of yeast in citrus products has been studied by several investigators. Recca and Mrak *(11)* identified 92 yeasts which had been isolated from fresh citrus, single-strength and concentrated juices. Species of *Candida* and *Saccharomyces (Zygosaccharomyces)* were the predominant flora found in citrus concentrates.

The interrelationships of concentration, use of preservatives, packaging, and mode of storage determine the degree to which viable microorganisms can be tolerated in processed concentrates. Particular attention must be given to bulk concentrates destined for re-manufacturing since unfavorable handling and storage conditions may cause product deterioration before final use.

Berry *et al (3)* studied the effects of temperature and juice concentration upon an osmophilic yeast, *Saccharomyces rouxii (Zygosaccharomyces vini)* isolated from single-strength orange juice. They found the yeast would grow in 58° Brix (highest concentration used) at 60° F but not at 50° F. When the concentration was 42° Brix, or lower, the yeast would readily grow at 40° F.

This report is concerned with the identification and characterization of a yeast isolated from several drums of a 65° Brix orange juice concentrate. The product had been held in storage at 35° F for a period of one year. Since the yeast had not been previously isolated from any part of the process it was assumed to be unique, probably entering the product subsequent to manufacture.

## EXPERIMENTAL

**Isolation and identification.** The yeast was isolated on orange serum agar medium as described by Stevens *(12)*. Identification was made according to the procedures of Lodder and Kreger-van Rij *(10)*. The yeast was compared with type species culture No. 51–26[b] obtained from the Centraalbureau voor Schimmel-cultures, Delft, Netherlands. Carbon assimilation patterns were made by a modification of the replication method of Beech, *et al (1)*.

**Substrate.** Orange juice concentrates of three densities and acid contents were used to determine the osmophilic characteristics of the isolated yeast strain. These were: 61.0° Brix and 4.7% acid (as citric acid); 65.6° Brix and 5.6% acid; and 70.7° Brix and 5.7% acid. Although these Brix values are not exactly 60, 65, and 70 degrees, they will be considered so in this paper. One hundred forty ml (5 oz) of orange concentrate substrate were placed in 8-oz crown-cap bottles and inoculated with 1 ml of suspension containing 16-hr old yeast cells. The inoculating medium was orange serum. The bottles were lightly capped. Duplicate inoculated samples were placed at each of 4 temperatures (20, 40, 60, and 80° F). Duplicate samples and plate counts were used to determine plating error. Prior to removing aliquots for plating each sample was stirred 45 sec with a sterile glass rod to insure even distribution of the yeast throughout the medium. Platings were made at zero time and at 30-day intervals for 120 days. The results were subjected to statistical analysis.

## RESULTS AND DISCUSSION

The yeast strain (54A)[c] isolated from bulk packed 65° Brix orange juice concentrate was identified as *Torulopsis magnoliae* Lodder and Kreger-van Rij 1952. When compared with the type species excellent agreement was found. This is well illustrated in a comparison of the carbon compounds assimilated by the two yeast cultures (Table 1).

TABLE 1
**Assimilation of carbon compounds by Torulopsis magnoliae**

| Carbon compounds | 54A Isolate | 51–26 Type species | Carbon compounds | 54A Isolate | 51–26 Type species |
|---|---|---|---|---|---|
| Glucose | + | + | Ethyl Alcohol | — | — |
| Galactose | + | + | Glycerol | + | + |
| L-Sorbose | + | + | i-Erythritol | — | — |
| Maltose | — | — | Adonitol | — | — |
| Sucrose | + | + | Dulcitol | — | — |
| Cellobiose | — | — | D-Mannitol | + | + |
| Trehalose | — | — | D-Sorbitol | + | + |
| Lactose | — | — | α Me-D-Glucoside | — | — |
| Melibiose | — | — | Salicin | + | + |
| Raffinose | — | — | Glucono δ Lactone | + | + |
| Melezitose | — | — | Ca-2-Keto Gluconate | + | + |
| Inulin | — | — | K-5-Keto Gluconate | — | — |
| D-Xylose | + | + | DL-Lactic Acid | — | — |
| L-Arabinose | + | + | Succinic Acid | + | + |
| D-Arabinose | — | — | Citric Acid | + | + |
| D-Ribose | + | + | i-Inositol | — | — |
| L-Rhamnose | — | — | | | |

[a] Presented at the Twentieth Annual Meeting of the Institute of Food Technologists, San Francisco, California, May 17, 1960.

[b] Culture number, yeast collection, Dept. of Food Science and Technology, U. C., Davis, Calif.

[c] Culture number, yeast collection, OPD, Sunkist Growers, Ontario, Calif.

This species of yeast was first isolated in 1942 from the flower of a magnolia in Holland. It has been subsequently found in fresh pollen and brood comb honey by Hajny *et al (5)*. They reported that under favorable conditions 40% of the glucose used by this yeast was converted to glycerol. Tanaka and Miller (unpublished data) also isolated a number of strains of this species from spoiled dried prunes. They found this osmophilic yeast to be capable of growth and fermentation in a 65° Brix concentrated sugar medium.

The results of the storage tests on the inoculated concentrates are shown in Figures 1, 2, and 3. The yeast was able to ferment all samples incubated at 60° and 80° F within 30 days. When stored at 20° and 40° F the population decreased with time of storage, with a single exception. A significant increase was noted in 60° Brix orange concentrate, stored at 40° F for 90 days. This increase continued for the duration of the test period.

The data were examined for significance by analysis of variance. In the figures the population levels are

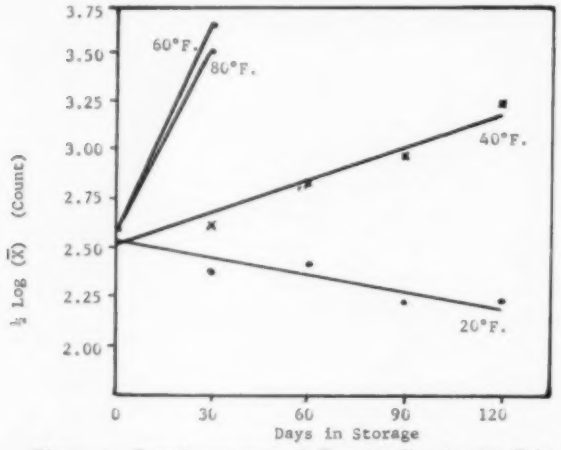



**Figure 1. Growth response of T. magnoliae in 60° Brix orange concentrate at various temperatures.**

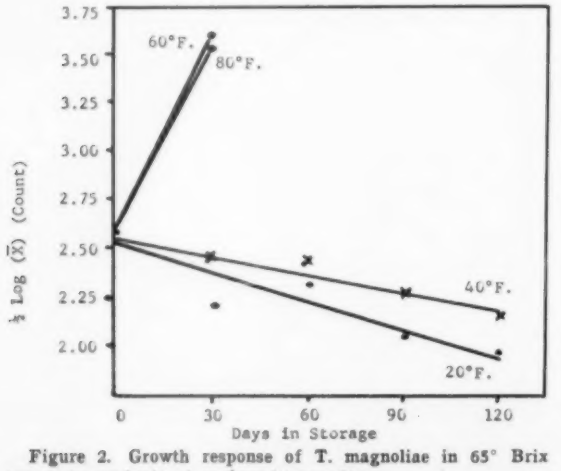



**Figure 2. Growth response of T. magnoliae in 65° Brix orange concentrate at various temperatures.**

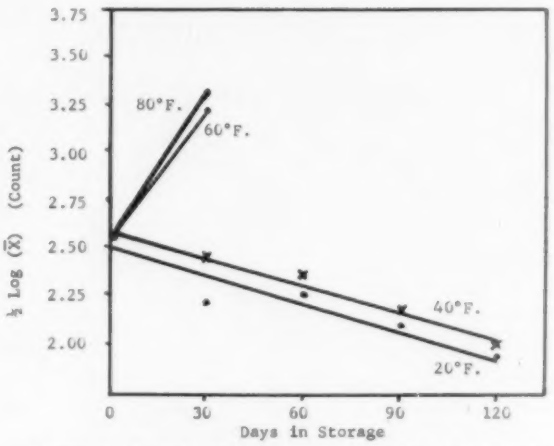



**Figure 3. Growth response of T. magnoliae in 70° Brix concentrate at various temperatures.**

expressed as ½ log ($\overline{X}$) of the total plate counts. The best straight line was fitted to the data for each set of conditions and the resultant slopes were found to be significant, except those representing the 30-day counts in the samples stored at 60° and 80° F. The increase in populations on the concentrates held at these two temperatures was not significantly different from one another. The rapid increase in population shown at 60° and 80° F was correlated with the fact that these samples fermented in the 30-day period.

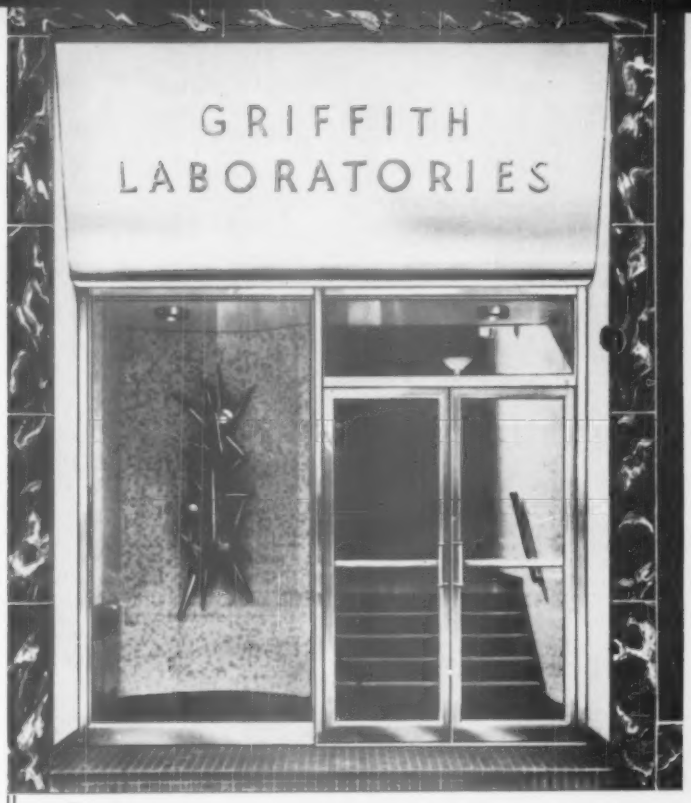
## SUMMARY

An osmophilic yeast *(Torulopsis magnoliae)* was isolated from 65° Brix concentrated orange juice and tested for its ability to ferment high density concentrates at various temperatures of storage. The yeast fermented all concentrates employed when stored at 60° and 80° F for 30 days. It also demonstrated significant growth in 60° Brix orange concentrate stored at 40° F for 90 days.

Common commercial practice has considered 40° F storage sufficiently low to protect 65° Brix orange concentrate against spoilage. However, the data in this paper show that if orange juice concentrate becomes inoculated with this yeast, lower temperatures are necessary for product protection.

## LITERATURE CITED

1. Beech, F. W., Carr, J. G., and Codner, R. C. A multipoint inoculator for plating bacteria or yeasts. *J. Gen. Microbiol.*, **13**, 408–410 (1955).
2. Beisel, C. G. Contamination control in a citrus plant. *Canner*, **133**, 23, 16 and **113**, 24, 19 (1951).
3. Berry, J. M., Witter, L. D., Folinazzo, J. F. Growth characteristic of spoilage organisms in orange juice and concentrates. *Food Technol.*, **10**, 553–556 (1956).
4. Faville, F. W., Hill, E. C., and Parish, E. C. Survival of microorganisms in concentrated orange juice. *Food Technol.*, **5**, 33 (1951).
5. Hajny, G. L., Hendershot, W. F., and Peterson, W. H. Factors affecting glycerol production by a newly isolated osmophilic yeast. *Appl. Microbiol.*, **8**, 5–11 (1960).

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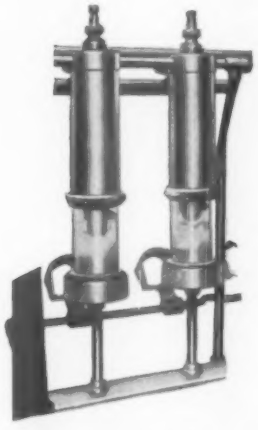

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6. HAYS, G. L., AND RIESTER, D. W. The control of "off-odor" spoilage in frozen concentrated orange juice. *Food Technol.*, 6, 386 (1952).
7. MURDOCK, D. I., AND BROKAW, C. H. An effective high pressure cleaning system for citrus concentration plants. *Proc. Fla. State Hort. Soc.* 1956.
8. MURDOCK, D. I., AND BROKAW, C. H. Sanitary control in processing citrus concentrates. I. Some specific sources of microbial contamination from fruit bins to extractors. *Food Technol.*, 12, 573–76 (1958).
9. MURDOCK, D. I., BROKAW, C. H., AND ALLEN, W. E. Plate type heat exchanger as a source of bacterial contamination in processing frozen concentrated orange juice. *Food Technol.*, 9, 187 (1955).
10. LODDER, J., AND KREGER-VAN RIJ, N. J. W. *The Yeasts—A Taxonomic Study.* 1952. North-Holland Pub. Co. Amsterdam, Netherlands.
11. RECCA, J., AND MRAK, E. M. Yeasts occurring in citrus products. *Food Technol.*, 6, 450–454 (1952).
12. STEVENS, J. S. Preparation of dehydrated media containing orange juice serum. *Food Technol.*, 8, 88–92 (1954).
13. TROY, V. S., AND SCHENCK, A. M. Microbiological and sanitary aspects of manufacturing citrus products. Annual Meeting of International Assoc. Milk and Food. N. Y. (1958). Published by Continental Can Co., Chicago, Ill.
14. VAUGHN, R. H., MURDOCK, D. I., AND BROKAW, C. H. Micro-organisms of significance in frozen citrus products. *Food Technol.*, 11, 92–95 (1957).
15. WOLFORD, E. R., AND BERRY, J. A. Bacteriology of slime in citrus processing plants with special reference to California. *Food Research*, 13, 340 (1948).

# Curing of Ham: A Study of Sodium Chloride Accumulation. II.

## Combined Effects of Time, Solution Concentration and Solution Volume[a, b]

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(Manuscript received May 21, 1959)

THE OBJECT of this study was to investigate the mechanisms involved in permeation of meat by sodium chloride solutions. Effects of time, solution concentration, and solution volume were evaluated. The literature dealing with inorganic ion diffusion into tissues was reviewed in the first part of this study *(1)*.

Quantitative evaluations of sodium chloride penetration into the mammalian muscle were reported by Callow *(1)*, who found that NaCl solution dehydrates the muscles, but as salt penetrates the muscle the osmotic equilibrium is changed and water returns into the tissue. From the study of water movement one may deduce the fate of sodium chloride. Fick's law of diffusion *(2)* cannot be rigorously applied to the diffusion of sodium chloride into muscle tissue, because the muscle tissue is not a simple solvent. Wistreich *et al (1)* have shown that certain nonspecific resistances to alkaline cation diffusion into pork muscle tissue are present, especially at temperatures lower than 18° C. The same authors have demonstrated the linearity of solution concentration and amount of NaCl accumulation in meat, and the accelerating effect of temperature. Mikulich *(3)* reported that the presence of calcium and magnesium ions in solution decreases significantly the permeability of fish flesh to sodium chloride.

### EXPERIMENTAL

Locally purchased pork hams were dissected and 4 muscles isolated; namely, *Biceps femoris*, *Rectus femoris*, *Semitendinosus*, and *Semimembranosus*. From these muscles cylindrical samples weighing approximately 100 g were prepared and placed in 100 ml beakers. Muscle fibers were parallel to beaker walls. To the exposed surface of the sample was firmly applied a 7 sq cm crosssection glass tube. Into the tube was poured a known volume of a sodium chloride solution of known concentration. The solution was then covered with 5 ml of mineral oil in order to prevent evaporation. Samples were allowed to stand in contact with the solution at 3° C. After a predetermined time the solution was poured out and chloride determined in the muscle sample. Chloride was corrected for initial muscle chloride, to yield added sodium chloride. The amount of

[a] Presented at the 19th Annual Meeting of the Institute of Food Technologists, Philadelphia, Pennsylvania, May 19, 1959.
[b] A paper of the Journal Series, N. J. Agricultural Experiment Station, Rutgers University, Department of Food Science.
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sodium chloride that diffused from solution into the muscle sample through 1 sq cm of contact area was called *accumulation value*. The accumulation value was expressed in mg of NaCl per cm.$^2$

Six series of experiments were performed. In the first 3 series, variables were time and solution concentration. In the second 3 series, variables were solution concentration and volume. Each series was composed of 2 to 5 replicate runs; each comprising 8 to 9 samples isolated from the same ham.

In the first series, solution concentration was 100 g/l, solution volume was 5 ml per cm$^2$ of contact area (35 ml per tube) and contact time was 1, 2, 4, 8, 12, 16, 24, 48, and 96 hr.

In the second and third series, procedure was the same except that solution concentrations were 200 and 300 g/l, respectively.

In the fourth series, solution concentration was 100 g/l, contact time was 24 hr, and solution volume was 2.14, 5.00, 7.86, and 10.71 ml/cm$^2$ (15, 35, 50, and 75 ml per tube).

The fifth and sixth series were similar to the fourth except for solution concentrations, which were 200 and 300 g/l, respectively.

## RESULTS AND DISCUSSION

Averages of results obtained in the first, second, and third series of this study are presented in Table 1. The accumulation value increased with time. The effect of raised solution concentration was to increase the accumulation value for any given time. This agrees with previous work *(4)* where accumulation value was related to solution concentration at constant time (24 hr).

Data from Table 1 are graphically presented in Figure 1. When the logarithm of accumulation value was plotted against logarithm of contact time, a straight line relationship resulted. Slope of this relationship was the same at different concentrations, but the intercepts differed. Curves similar to the ones in Figure 1 were obtained when data from individual runs were plotted.

The curves in Figure 1 may be expressed by the following empirical equations:

$$\log A = 0.4 \log t + 1.19 \quad (1)$$
$$\log A = 0.4 \log t + 1.45 \quad (2)$$
$$\log A = 0.4 \log t + 1.66 \quad (3)$$

Where:

A—is accumulation value in mg/cm$^2$
t—is time in hours

Equations (1), (2), and (3) may be expressed by the general form:

$$\log A = 0.4 \log t + i \quad (1a)$$

TABLE 1

**Effect of time and solution concentration on sodium chloride accumulation value in pork thigh muscles at 3° C**

| Time hours | 100 g/l solution | | 200 g/l solution | | 300 g/l solution | |
|---|---|---|---|---|---|---|
| | Average | Range | Average | Range | Average | Range |
| 1 | 15.5 | 0.4 | 27.9 | 5.4 | 45.8 | 5.7 |
| 2 | 17.8 | 1.3 | 37.6 | 8.4 | 58.6 | 6.3 |
| 4 | 25.8 | 3.0 | 49.4 | 8.6 | 77.7 | 6.8 |
| 8 | 32.1 | 3.0 | 65.1 | 6.4 | 94.2 | 0.6 |
| 12 | 40.1* | 0.0* | 77.9 | 12.1 | 119.6* | 0.0* |
| 16 | 44.5 | 3.6 | 90.2 | 10.6 | 112.1 | 12.1 |
| 24 | 55.8 | 0.3 | 103.7 | 9.4 | 132.6 | 7.1 |
| 48 | 76.1 | 3.6 | 146.0 | 29.7 | 189.8 | 3.5 |
| 96 | 110.0 | 0.8 | 216.5 | 25.0 | 338.6 | 14.8 |

* Based on one determination only.

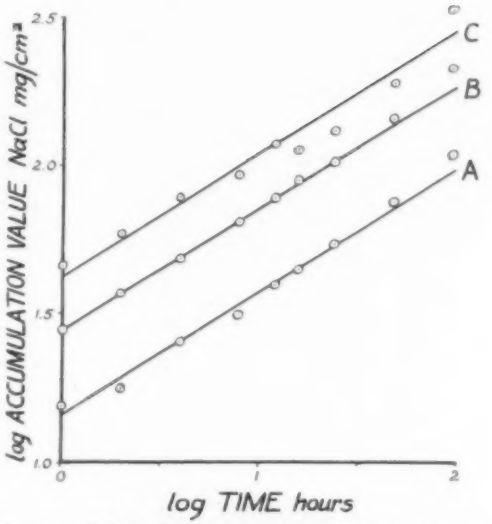


**Figure 1. Effect of time and solution concentration on the accumulation of sodium chloride in pork thigh muscles. Curve A-100g/1 NaCl solution. Curve B-200g/1 NaCl solution. Curve C-300g/1 NaCl solution.**

Where:

i—is the intercept value

Previous work *(4)* has shown that if time is kept constant at 24 hr, the accumulation value—solution concentration relationship obeys the following equation:

$$A = 0.5\ C \quad (4)$$

Where:

C—is solution concentration in g/l.

Thus the intercept values i must vary linearly with solution concentration, for they express the accumulation value at 1 hr. By combining equations (1a) and (4) one obtains:

$$\log 0.5\ C = 0.4 \log 24 + i \quad (5)$$
$$i = \log 0.5\ C - 0.55 \quad (6)$$

By substituting (6) into (1a) one obtains:

$$\log A = 0.4 \log t + \log 0.5\ C - 0.55 \quad (7)$$

Equation (7) expresses the correlation of accumulation value to both solution concentration and time. This equation is valid only if the solution volume is 5 ml/cm$^2$ at temperature of 3° C.

Results of the fourth, fifth, and sixth series of experiments are presented in Table 2. The accumulation value increased with solution volume. This increase occurred at all solution concentrations used in these experiments. The data from Table 2 are graphically presented in Figure 2.

The effect of solution volume on accumulation value seems to be more marked at higher NaCl concentrations. This effect could be explained by the dilution effect of moisture drawn from the tissue by the solution, and by solution concentration drop due to sodium chloride diffusion into the tissue. In a larger volume these 2 factors have a smaller relative effect on concentration than in a smaller volume.

TABLE 2

**Effect of solution volume and concentration on sodium chloride accumulation in pork thigh muscles at 3° C in 24 hours**

| Solution volume | Solution concentration | Average accumulation value | Range |
|---|---|---|---|
| *ml/cm²* | *g/l* | *mg/cm²* | *mg/cm²* |
| 2.14 | 100 | 44.6 | 7.7 |
| 5.00 | 100 | 53.8 | 8.2 |
| 7.86 | 100 | 55.4 | 1.8 |
| 10.71 | 100 | 59.9 | 5.7 |
| 2.14 | 200 | 88.1 | 15.2 |
| 5.00 | 200 | 102.9 | 14.3 |
| 7.86 | 200 | 101.3 | 9.7 |
| 10.71 | 200 | 112.2 | 17.6 |
| 2.14 | 300 | 126.5 | 43.3 |
| 5.00 | 300 | 137.2 | 35.5 |
| 7.84 | 300 | 150.0 | 42.5 |
| 10.71 | 300 | 173.0 | 45.7 |

The curves in Figure 2 may be expressed by the following empirical equations:

$$A = 1.86\ V + 41.5 \text{ (for the 100 g/l curve)} \quad (8)$$

$$A = 2.75\ V + 82.5 \text{ (for the 200 g/l curve)} \quad (9)$$

$$A = 5.31\ V + 113.5 \text{ (for the 200 g/l curve)} \quad (10)$$

Where:

V—is the solution volume in ml/cm² of contact area.

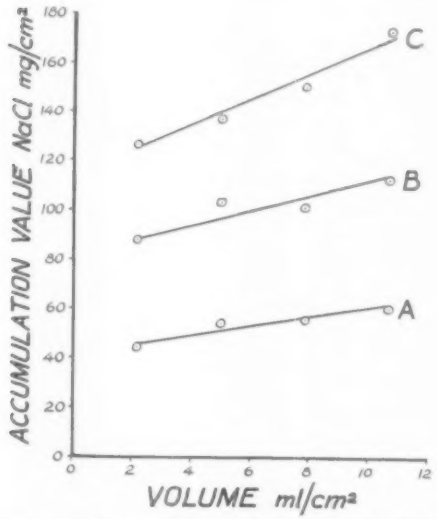


**Figure 2. Effect of solution volume and concentration on sodium accumulation value in pork thigh muscles. Curve A-100g/1 NaCl Solution. Curve B-200g/1 NaCl Solution. Curve C-300g/1 NaCl Solution.**

The above equations apply only to volumes greater than 2.1 ml/cm².

Both the slopes and intercepts of equations (8), (9), and (10) appear to vary directly with solution concentration. By analysis of data from Table 2 an equation correlating accumulation value to solution concentration and volume may be construed. This equation is as follows:

$$A = 0.02CV + 0.40\ C \quad (11)$$

Values computed by use of equation (11) may be easily cross checked by use of equation (7). A close agreement is found by such cross checking.

By combining equations (1a) and (11) a composite equation is obtained.

$$\log A = 0.4 \log t - \log C + \log (2V + 40) - 2.55 \quad (12)$$

Equation (12) expresses the correlation between accumulation value, time, solution volume, and solution concentration. The precision of the equation (12) is within ± 10% range for contact times of less than 24 hr. For longer contact times the error increases to ± 20%. Investigations of effects of muscle pH, intracellular fat, salty purity, and ionic composition of the muscle should permit the elimination of some of the error now inherent in the calculations of accumulation value.

## SUMMARY

Effects of time, solution volume, and solution concentration on sodium chloride diffusion into pork muscle were studied. Accumulation of sodium chloride varied linearly with solution concentration and volume. The accumulation value-time relationship was logarithmic. An equation correlating the above factors was derived.

## LITERATURE CITED

1. Callow, E. H. The action of salt and other substances used in curing of ham and bacon. *Brit. J. Nutrition*, 1, 263 (1947).
2. Fick, A. Ueber diffusion. *Ann. Physik und Chemie.*, (Pog), 94, (170), 59 (1855).
3. Mikulich, Ya. V. Effect of salt composition on the salting process and quality of salted fish. *Izvest. Tikhookean Nauch. Issled. Inst. Rybnogo Khoz. i Okeanog.*, 44, 209 (1957).
4. Wistreich, H. E., Morse, R. E., and Kenyon, L. J. Curing of ham; a study of sodium chloride accumulation. I. Methods; effect of cations, muscles, temperature, and solution concentration. *Food Technol.*, 13, 441 (1959).

# Low Temperature Handling of Sterilized Foods. V.

## Biochemical Changes in Storage[a]

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(Manuscript received June 2, 1960)

In recent years, advantage has been taken of the logarithmic order of thermal death of bacteria as opposed to first order kinetics of biochemical alterations during thermal processing to develop a number of commercial high temperature-short time (HTST) thermal processes for canned product sterilization. Such processes can produce food products which are of relatively high initial quality.

Since it has been established that many biochemical quality factors are not storage stable in most conventionally canned foods under ambient temperature conditions *(7)*, it would be expected that equal or greater instability will be found in HTST processed products due to the greater concentration of unstable reactants, and that low temperature storage might be quite beneficial to retention of qualities represented by these biochemicals. It was the intention of this investigation to determine some of the biochemical changes proceeding in certain HTST processed canned foods and in their conventionally processed counterparts under various storage temperatures.

### EXPERIMENTAL PROCEDURE

The following high temperature-short time and conventionally processed products were studied: tomato juice, green beans, whole kernel sweet corn, cream of potato soup, cream of shrimp soup, green pea with ham soup, and oyster stew. Preparation, canning and thermal processing are described in other papers of this series *(3, 4)*. HTST samples were packed in 211 x 011 plain cans[b]; conventionally processed foods were packed in No. 2 (307 x 409) plain cans. Samples were stored at 35° F, 50° F and 80° F; 8 cans of HTST samples and one can of conventionally processed were removed from each storage temperature after 3, 6 and 12 months. Samples from HTST cans were combined for analysis.

All products except green pea with ham soup were analyzed for thiamine content; whole kernel sweet corn and green beans were analyzed for riboflavin content. Ascorbic acid determinations were made on tomato juice, green beans, whole kernel sweet corn, cream of potato soup and on green pea with ham soup. Beta-carotene analyses were made on oyster stew and yellow sweet corn.

Determinations of pH and total acidity were made on cream of potato soup, oyster stew, green pea with ham soup, whole kernel sweet corn, tomato juice, green beans, and cream of shrimp soup. Changes in trimethylamine content were measured in the two shellfish-containing products. Color evaluations were made on each product by tristimulus reflectance colorimetry.

**Vitamin assays.** All vitamin assays were performed using chemical methods. Beta-carotene contents of products were determined by the chromatographic method. Thiamine contents were determined by the thiochrome method; riboflavin contents were determined by the fluorometric method. Reduced ascorbic acid was measured by the indophenol-xylene extraction method *(1)*.

**Color.** Color of each product was measured using Gardner Automatic Color Difference Meter (Gardner Laboratories, Bethesda, Maryland). Tomato juice was read by filling a cylindrical lucite cell 2½ inches inside diameter by one inch inside height, with juice; covering the cell with a ceramic standard red plate previously used for standardizing the instrument at $R_d = 5.6$, $a = +47.7$, and $b = +16.0$; and placing the cell over the 2¼ inch opening of the instrument for reading.

Cream of potato soup, cream of shrimp soup, oyster stew, and green pea with ham soup were slurried to a homogenate in a Waring blender before placement in the cell. Green beans and whole kernel corn were drained of liquid prior to slurrying. Standard green plate used for green beans and green pea with ham soup had a reading of $R_d = 29.3$, $a = -11.1$, $b = +14.5$. A standard white plate having a reading of $R_d = 79.5$, $a = -0.6$, and $b = +0.1$ was used as the standard for all other products.

**Other analyses.** Total acidity was determined by diluting tomato juice or slurry with distilled water and titrating with 0.1N NaOH to a pH 8 endpoint. Total acidity is reported as milliequivalents of NaOH required to neutralize the acid present in 10 g of sample. pH was determined by direct reading with Beckman pH meter.

Trimethylamine content of the two products containing shellfish was determined by colorimetric determination as the picrate salt *(2)*. Sample was blended with trichloroacetic acid and filtered. Filtrate was treated with formalin solution and extracted with toluene. Extract was converted to picrate salt and quantity of trimethylamine was determined colorimetrically by comparing to standard curve of picrate salt.

### RESULTS AND DISCUSSION

**Beta-carotene changes in storage.** Initial beta-carotene content[c] of oyster stew was not significantly changed after 12 months at all temperatures in either HTST or conventionally processed product.

Conventionally processed whole kernel sweet corn had an initial beta-carotene content significantly

[a] Presented before the Twentieth Annual Meeting, Institute of Food Technologists, San Francisco, May 18, 1960.

[b] HTST procedure used was one of expedience and was incapable of producing products equal in quality to those which can be produced by processes in which the food is heated for sterilization in bulk before filling. In the latter type of process, sterilization is accomplished in a matter of seconds, whereas the processes using in the work herein reported varied from 1–3 min at 300° F.

[c] The expression "initial content" in the following paragraphs means "content within 72 hr after processing."

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higher than that found in HTST processed corn. Storage of conventionally processed product for 12 months at 35° F and 50° F, and storage of HTST processed product at 35° F for 12 months resulted in no significant changes in beta-carotene content. Significant losses were noted in conventionally processed corn after 6 months storage at 80° F and in HTST processed samples after 12 months at 50° F and 80° F (Table 1).

TABLE 1

Beta carotene content of canned whole kernel sweet corn in storage

| Storage temp (° F) | Storage time (months) | | | |
|---|---|---|---|---|
| | 0 | 3 | 6 | 12 |
| | (mcg/100 g) | (mcg/100 g) | (mcg/100 g) | (mcg/100 g) |
| Conventionally processed | | | | |
| 35 | 113 | 103 | 78 | 107 |
| 50 | | 100 | 99 | 107 |
| 80 | | 90 | 62 | 67 |
| | | 98 | 80 | 94 |
| HTST processed | | | | |
| 35 | 97 | 124 | 73 | 95 |
| 50 | | 110 | 83 | 71 |
| 80 | | 114 | 99 | 64 |
| | | 116 | 85 | 77 |

**Thiamine changes during storage.** There were no significant differences between initial thiamine contents of tomato juice processed conventionally and by HTST methods. HTST tomato juice thiamine content did not change in storage, but conventionally processed tomato juice did show significant thiamine losses after 12 months at 50° F and 80° F.

Initial thiamine content of cream of potato soup was higher in HTST processed product than in conventionally processed. Significant storage losses were observed in conventionally processed product at 80° F and in HTST processed product at all three storage temperatures after 12 months.

Initial thiamine content of oyster stew processed by HTST methods was significantly higher than that found in conventionally processed samples. Conventionally processed samples displayed losses after 12 months at 80° F.

Initial thiamine content of cream of shrimp soup processed by HTST method was significantly higher than that processed by conventional methods.

HTST processed green beans had an initial thiamine content almost double the conventionally processed sample's initial content. Significant storage losses were observed in both conventionally and HTST processed samples stored 12 months at 80° F.

Storage losses were noted after 3 months at 80° F in conventionally processed whole kernel sweet corn and after 6 months at all 3 storage temperatures in HTST processed samples (Table 2).

Thiamine, a heat labile constituent, is evidently better preserved in HTST processes than by conventional processing techniques for all but tomato juice of the products evaluated. Significant storage losses of thiamine content of both HTST and conventionally processed were observed in all but two products after 12 months storage at 80° F, but there is no indication that the processing method has any effect on storage stability of thiamine in any of the products. However, it is evident that lower temperature storage significantly improves thiamine retention in both HTST and conventionally processed products.

**Riboflavin.** Significant riboflavin losses were observed in conventionally processed green beans after 12 months at all three temperatures and in HTST-processed after 6 months at 50° F and 80° F (Table 3).

**Reduced ascorbic acid retention.** Reduced ascorbic acid content of all products involved in this study was extremely low. Soups were prepared by conventional

TABLE 2

Thiamine content of canned whole kernel sweet corn, green beans, tomato juice, cream of potato soup, and oyster stew during storage

| Storage temp (° F) | Storage time (months) | | | |
|---|---|---|---|---|
| | 0 | 3 | 6 | 12 |
| | (mg/100 g) | (mg/100 g) | (mg/100 g) | (mg/100 g) |
| Whole Kernel Sweet Corn: | | | | |
| Conventionally processed | | | | |
| 35 | 0.031 | 0.037 | 0.025 | 0.038 |
| 50 | | 0.035 | 0.028 | 0.038 |
| 80 | | 0.023 | 0.023 | 0.022 |
| | | 0.032 | 0.025 | 0.033 |
| HTST processed | | | | |
| 35 | 0.038 | 0.050 | 0.028 | 0.026 |
| 50 | | 0.045 | 0.024 | 0.027 |
| 80 | | 0.038 | 0.025 | 0.027 |
| | | 0.044 | 0.026 | 0.027 |
| Green Beans: | | | | |
| Conventionally processed | | | | |
| 35 | 0.019 | 0.024 | 0.028 | 0.021 |
| 50 | | 0.024 | 0.026 | 0.019 |
| 80 | | 0.022 | 0.026 | 0.015 |
| | | 0.023 | 0.027 | 0.018 |
| HTST processed | | | | |
| 35 | 0.036 | 0.033 | 0.037 | 0.036 |
| 50 | | 0.033 | 0.035 | 0.032 |
| 80 | | 0.028 | 0.036 | 0.025 |
| | | 0.031 | 0.036 | 0.031 |
| Tomato Juice: | | | | |
| Conventionally processed | | | | |
| 35 | 0.046 | 0.046 | 0.047 | 0.043 |
| 50 | | 0.056 | 0.047 | 0.037 |
| 80 | | 0.053 | 0.046 | 0.037 |
| | | 0.052 | 0.047 | 0.039 |
| HTST processed | | | | |
| 35 | 0.048 | 0.043 | 0.043 | 0.052 |
| 50 | | 0.065 | 0.043 | 0.044 |
| 80 | | 0.062 | 0.041 | 0.047 |
| | | 0.057 | 0.042 | 0.048 |
| Cream of Potato Soup: | | | | |
| Conventionally processed | | | | |
| 35 | 0.072 | ..... | 0.065 | 0.074 |
| 50 | | ..... | 0.061 | 0.064 |
| 80 | | ..... | 0.060 | 0.053 |
| | | | 0.062 | 0.064 |
| HTST processed | | | | |
| 35 | 0.087 | ..... | 0.087 | 0.053 |
| 50 | | ..... | 0.078 | 0.059 |
| 80 | | ..... | 0.094 | 0.043 |
| | | | 0.086 | 0.052 |
| Oyster Stew: | | | | |
| Conventionally processed | | | | |
| 35 | 0.059 | ..... | 0.057 | ..... |
| 50 | | ..... | 0.056 | 0.059 |
| 80 | | ..... | 0.056 | 0.044 |
| | | | 0.056 | 0.054 |
| HTST processed | | | | |
| 35 | 0.078 | 0.067 | 0.077 | 0.082 |
| 50 | | 0.075 | 0.076 | 0.086 |
| | | 0.061 | 0.070 | 0.071 |
| | | 0.068 | 0.074 | 0.083 |

TABLE 3

Riboflavin content of canned beans in storage

| Storage temp (° F) | Storage time (months) | | | |
|---|---|---|---|---|
| | 0 | 3 | 6 | 12 |
| | (mg/100 g) | (mg/100 g) | (mg/100 g) | (mg/100 g) |
| Conventionally processed | 0.024 | 0.020 | 0.021 | 0.016 |
| 35 | | 0.018 | 0.029 | 0.012 |
| 50 | | 0.038 | 0.019 | 0.010 |
| 80 | | 0.025 | 0.023 | 0.013 |
| HTST processed | 0.032 | 0.032 | 0.030 | 0.027 |
| 35 | | 0.036 | 0.026 | 0.018 |
| 50 | | 0.047 | 0.022 | 0.014 |
| 80 | | 0.038 | 0.026 | 0.020 |

cooking techniques prior to canning and thus were not expected to have high reduced ascorbic acid contents; tomato juice for this study was prepared from previously processed juice, and the double process undoubtedly reduced the content to almost negligible quantities. Canned green beans and whole kernel sweet corn do not generally contain high reduced ascorbic acid contents.

Thus, no significant differences were observed between initial reduced ascorbic acid contents of HTST processed green beans and tomato juice and those of the same product processed by conventional methods, nor were any significant storage changes noted.

Initial retentions of reduced ascorbic acid in conventionally processed cream of potato soup and whole kernel sweet corn were higher than in HTST processed.

Significant losses of reduced ascorbic acid were noted in conventionally processed whole kernel sweet corn after only 3 months storage at 80° F; samples held at 50° F and below retained most of their reduced ascorbic acid content for 12 months. Similar results were noted for HTST processed whole kernel sweet corn.

No significant storage changes were observed in HTST processed green pea with ham soup but losses of almost half were noted in conventionally processed after 12 months at 80° F (Table 4).

The high thermal sensitivity of ascorbic acid coupled with the processes given the products combined to lower analyzed values to almost negligible values, while other less heat labile components were less affected and so more readily analyzed. Results obtained on reduced ascorbic acid contents could not be accepted as indicative of changes which might occur in less vigorously processed samples. While no advantages of HTST over conventional processing have been shown, it is evident that 80° F storage temperatures are not advantageous to ascorbic acid retention in products studied.

**Color changes in storage.** Red-green hue of products is indicated in "a" value, more positive values indicating more red, and less positive values meaning less red. HTST processed tomato juice had a higher "a" value than did conventionally processed throughout the 12 month study. Retention of red color was benefited by storage at 35° F. After 12 months storage at 80° F, red color of both HTST and conventionally stored samples was significantly decreased with no significant difference attributable to original processing method.

TABLE 4

Reduced ascorbic acid content of canned whole kernel sweet corn and green pea with ham soup in storage

| Storage temp (° F) | Storage time (months) | | | |
|---|---|---|---|---|
| | 0 | 3 | 6 | 12 |
| Whole Kernel Sweet Corn: | (mg/100 g) | (mg/100 g) | (mg/100 g) | (mg/100 g) |
| Conventionally processed | 5.7 | 5.3 | .... | 4.5 |
| 35 | | 3.6 | .... | 4.5 |
| 50 | | 2.9 | .... | 3.8 |
| 80 | | 3.9 | | 4.3 |
| HTST processed | 3.4 | 3.6 | 1.8 | 3.2 |
| 35 | | 2.8 | 3.1 | 2.5 |
| 50 | | 2.4 | 2.6 | 0.3 |
| 80 | | 3.6 | 2.5 | 2.0 |
| Green Pea with Ham Soup: | | | | |
| Conventionally processed | 1.9 | 1.7 | 1.7 | 1.8 |
| 35 | | 1.8 | 1.7 | 1.7 |
| 50 | | 1.8 | 1.6 | 1.1 |
| 80 | | 1.8 | 1.7 | 1.5 |
| HTST processed | 1.9 | 2.0 | 1.9 | 2.3 |
| 35 | | 2.2 | 1.8 | 2.4 |
| 50 | | 2.3 | 2.0 | 2.2 |
| 80 | | 2.2 | 1.9 | 2.3 |

Yellow-blue hues are indicated by "b" values, more positive meaning more yellow, and vice versa. HTST processed whole kernel corn had significantly more yellow than did conventionally processed, but no significant color changes were noted in storage, due either to storage per se or to any specific storage condition.

HTST processed green beans had more green hue in samples processed conventionally. Again, however, no significant changes were observed due either to storage or to a storage condition. Analagous results were observed in green pea with ham soup, indicating that processing method has a profound effect upon green color, but that storage within experimental limitations exerted no significant effect upon color *(5)*.

In oyster stew, there were significant color differences to the advantage of HTST processing, and these advantages carried over throughout the storage period, with no specific storage condition exerting any special influence upon color change in storage. In

TABLE 5

Changes in Gardner colorimeter "a" value of canned tomato juice during storage

| Storage temp (° F) | Storage time (months) | | | |
|---|---|---|---|---|
| | 0 | 3 | 6 | 12 |
| Conventionally processed | +21.3 | +20.8 | +21.3 | +23.1 |
| 35 | | +20.9 | +21.5 | +13.5 |
| 50 | | +21.3 | +21.8 | +13.8 |
| 80 | | +21.0 | +21.5 | +16.8 |
| HTST processed | +22.7 | +23.9 | +22.0 | +24.2 |
| 35 | | +21.8 | +21.6 | +14.2 |
| 50 | | +22.2 | +22.3 | +14.7 |
| 80 | | +22.6 | +22.0 | +17.7 |

some contrast, however, neither processing method nor storage resulted in any changes in color of cream of potato soup. Analagous results were observed with cream of shrimp soup.

From these results, it appears that storage conditions exert a significant effect upon product color of tomato juice only. The relatively mild storage conditions used in this study did not allow manifestation of previously reported effects of ambient temperature storage on color. In the case of some products colored red or green, processing method may have a significant effect on color retention.

**Other biochemical components.** There were no significant differences in initial total acidity between HTST and conventionally processed tomato juice, cream of potato soup, or whole kernel sweet corn, nor were any changes or differences observed in storage. Similar results were observed in pH values. Total acidity of HTST processed oyster stew was significantly higher than in conventionally processed, and after storage at 50° F and 80° F for 12 months, significant increases were observed in samples from both processing methods. Similar initial results were noted in green pea with ham soup.

Initial total acidity was higher in conventionally processed cream of shrimp soup than in HTST processed. Significant increases were noted after only 6 months storage of HTST processed samples at 80° F. HTST processed green beans had a higher initial pH than did conventionally processed; and after 6 months storage at 80° F, samples from both processing methods showed significant decreases (Table 6).

It has been indicated previously that reduction of trimethylamine oxide to trimethylamine can occur in canned fish and that this reaction can be a contributing factor to storage deterioration of canned fish products *(6)*. Trimethylamine content of oyster stew processed by both methods was the same, indicating that processing method had no significant effect upon the reduction. However, storage and storage condition exerted a profound effect upon trimethylamine content of oyster stew after only six months storage. The rate of trimethylamine formation was slowest at 35° F but still significant even at this temperature, and very much more rapid at higher temperatures especially in HTST samples. Similar results were observed in cream of shrimp soup (Table 7).

## SUMMARY

Several biochemical changes have been studied in a number of products processed by high temperature-short time and conventional canning sterilization methods and stored for 12 months at 35° F, 50° F and 80° F. Beta-carotene content of oyster stew was not affected by either processing method or storage, while content of whole kernel sweet corn was somewhat less deteriorated by HTST processing than by conventional processing. Both storage temperature and storage time had significant effects on beta-carotene contents, longer times and higher temperatures causing greater storage losses.

**TABLE 6**

**Total acidity and pH of canned products in storage**

| Storage temp (° F) | Total acidity (meq/10 g) Storage time (months) | | | |
|---|---|---|---|---|
| | 0 | 3 | 6 | 12 |
| Oyster Stew: | | | | |
| Conventionally processed | | | | |
| 35 | 0.25 | 0.25 | 0.25 | 0.24 |
| 50 | | 0.25 | 0.24 | .027 |
| 80 | | 0.27 | 0.25 | 0.29 |
| | | 0.26 | 0.25 | 0.27 |
| HTST processed | | | | |
| 35 | 0.15 | 0.15 | 0.18 | 0.19 |
| 50 | | 0.15 | 0.18 | 0.21 |
| 80 | | 0.15 | 0.19 | 0.22 |
| | | 0.15 | 0.18 | 0.21 |
| Green Pea with Ham Soup: | | | | |
| Conventionally processed | | | | |
| 35 | 0.25 | 0.28 | 0.25 | 0.24 |
| 50 | | 0.27 | 0.29 | 0.21 |
| 80 | | 0.28 | 0.29 | 0.22 |
| | | 0.27 | 0.28 | 0.22 |
| HTST processed | | | | |
| 35 | 0.21 | 0.17 | 0.15 | 0.23 |
| 50 | | 0.22 | 0.19 | 0.36 |
| 80 | | 0.26 | 0.26 | 0.46 |
| | | 0.22 | 0.20 | 0.35 |
| Cream of Shrimp Soup: | | | | |
| Conventionally processed | | | | |
| 35 | 0.09 | 0.07 | 0.07 | 0.08 |
| 50 | | 0.12 | 0.08 | 0.08 |
| 80 | | 0.08 | 0.07 | 0.09 |
| | | 0.09 | 0.07 | 0.08 |
| HTST processed | | | | |
| 35 | 0.06 | 0.08 | 0.07 | 0.05 |
| 50 | | 0.07 | 0.07 | 0.06 |
| 80 | | 0.05 | 0.25 | 0.10 |
| | | 0.06 | 0.13 | 0.07 |
| | pH | | | |
| Green Beans: | | | | |
| Conventionally processed | 5.6 | | | |
| 35 | | 6.0 | 5.5 | 5.6 |
| 50 | | 5.9 | 6.6 | 5.5 |
| 80 | | 5.7 | 5.3 | 5.2 |
| | | 5.9 | 5.8 | 5.4 |
| HTST processed | 5.9 | | | |
| 35 | | 6.2 | 5.8 | 5.8 |
| 50 | | 6.3 | 5.7 | 5.7 |
| 80 | | 5.8 | 5.3 | 5.2 |
| | | 6.1 | 5.6 | 5.6 |

**TABLE 7**

**Trimethylamine content of canned oyster stew and cream of shrimp soup in storage**

| Storage temp (° F) | Storage time (months) | | | |
|---|---|---|---|---|
| | 0 | 3 | 6 | 12 |
| | *(mg/100 g)* | *(mg/100 g)* | *(mg/100 g)* | *(mg/100 g)* |
| Oyster Stew: | | | | |
| Conventionally processed | | | | |
| 35 | 0.08 | 0.08 | 0.41 | 0.73 |
| 50 | | 0.05 | 0.43 | 0.55 |
| 80 | | 0.11 | 0.43 | 0.63 |
| | | 0.08 | 0.42 | 0.64 |
| HTST processed | | | | |
| 35 | 0.08 | 0.07 | 0.43 | 0.64 |
| 50 | | 0.03 | 0.44 | 0.76 |
| 80 | | 0.09 | 0.44 | 0.74 |
| | | 0.06 | 0.44 | 0.71 |
| Cream of Shrimp Soup: | | | | |
| Conventionally processed | | | | |
| 35 | 1.15 | 1.06 | 1.78 | 1.72 |
| 50 | | 1.72 | 1.75 | 2.07 |
| 80 | | 1.94 | 2.28 | 1.98 |
| | | 1.57 | 1.94 | 1.92 |
| HTST processed | | | | |
| 35 | 1.01 | 1.92 | 1.58 | 2.06 |
| 50 | | 1.79 | 1.89 | 2.79 |
| 80 | | 2.58 | 2.10 | 1.88 |
| | | 2.10 | 1.86 | 2.24 |

Thiamine contents of tomato juice, cream of potato soup, oyster stew, cream of shrimp soup, green beans and whole kernel sweet corn were either affected equally by HTST process and the conventional process or decreased markedly less by the HTST processing methods, by shorter storage periods and by lower storage temperatures thus demonstrating the thermal lability of this component. No differences were observed in initial riboflavin contents between HTST and conventionally processed whole kernel sweet corn, but HTST processing did have a beneficial riboflavin retention effect on green beans. Whereas no storage effects on riboflavin were observed in the former product, green beans were greatly benefited by shorter times and lower temperatures of storage.

Ascorbic acid contents of products studied in these experiments were too low to demonstrate any valid results with respect to processing method or storage condition.

The red color of tomato juice and the green color of green beans and green pea with ham soup were significantly less affected by HTST processing than by conventional processing and by low temperature storage as compared to storage at 80° F. Trimethylamine contents of shellfish-containing canned products studied were not affected more by one processing method than by the other but did increase during storage, lesser increases being noted for shorter storage periods and at lower storage temperatures.

Results of this study clearly demonstrate that HTST processing methods can give a product which is equivalent or superior to conventionally canned product with respect to components investigated, and that products processed by either method are materially benefited by storage temperatures below 50° F. There was no evidence to the effect that HTST processed products, having an initially higher concentration of reactants deteriorated faster than similar conventionally processed canned products.

**Acknowledgments**

Sincere appreciation is expressed to Dr. Arnold I. Epstein, formerly of Rutgers University Department of Food Science, who was in charge of processing the products studied, and to Mrs. Grace Mutz of Whirlpool Corporation Research Laboratories who provided technical assistance in biochemical analyses.

LITERATURE CITED

1. Association of Vitamin Chemists, Inc. *Methods of Vitamin Assay.* 1951. Interscience, New York, N. Y.
2. Dyer, W. J. Amines in fish muscle. I. Colorimetric determination of trimethylamine as the picrate salt. *J. Fisheries Research Board Canada*, **6**, 351 (1945).
3. Epstein, Arnold I., and Ball, C. Olin. Low temperature handling of sterilized foods. I. Design of equipment and outline of processes used. *Food Technol.*, **14**, 363 (1960).
4. Epstein, Arnold I., Lauro, G. J., Stier, E. F., and Ball, C. Olin. Low temperature handling of sterilized foods. IV. The effects of storage temperature on the quality of frozen and of HTST and conventionally sterilized canned vegetables, soup, and evaporated milk. Presented before 20th Annual Meeting, Institute of Food Technologists, San Francisco, May 18, 1960.
5. Epstein, Arnold I., Stier, E. F., and Ball, C. Olin. Low temperature handling of sterilized foods. II. The storage stability of color of high temperature short time sterilized green peas. Presented before 20th Annual Meeting, Institute of Food Technologists, San Francisco, May 18, 1960.
6. Farber, Lionel, and Ferro, Michael. Volatile reducing substances (VRS) and volatile nitrogen compounds in relation to spoilage in canned fish. *Food Technol.*, **10**, 303 (1956).
7. Guerrant, N. B., Fardig, O. B., Vavich, M. G., and Ellenberger, H. E. Nutritive value of canned food. Influence of temperature and time of storage on vitamin content. *Ind. Eng. Chem.*, **40**, 2258 (1948).

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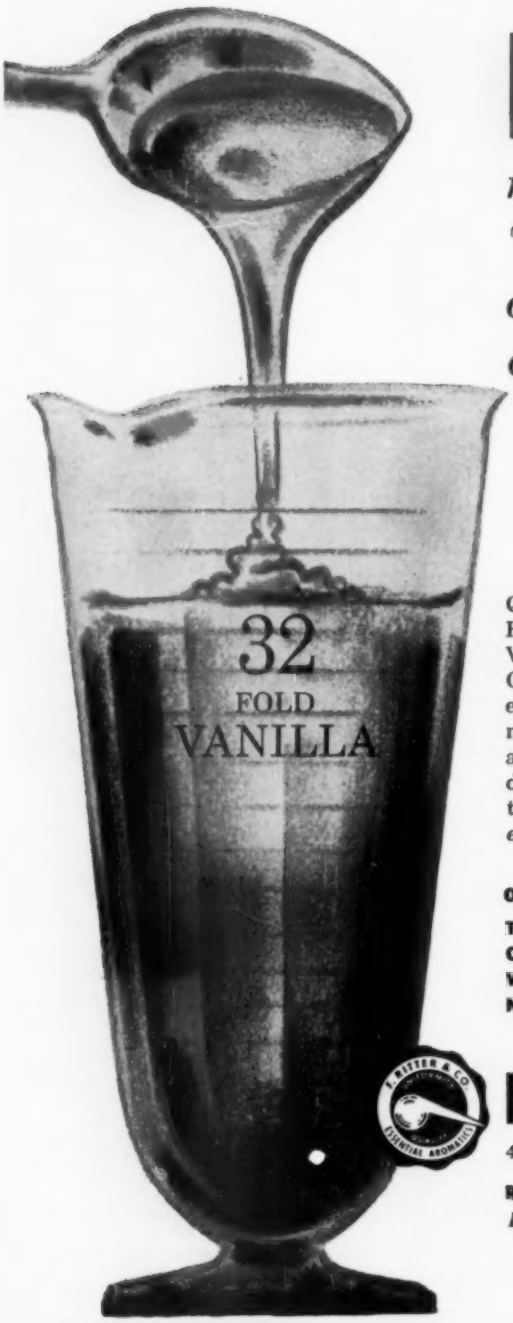


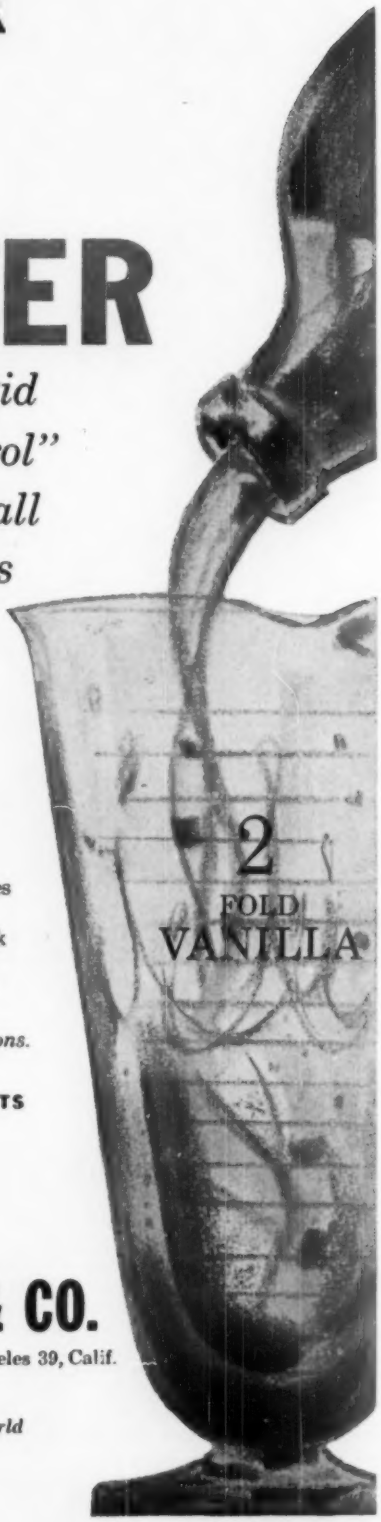


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# Viscometric Behavior in Relation to Evaporation of Fruit Purees

(Manuscript received November 6, 1959)

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FRUIT AND VEGETABLE PUREES present special problems in flow and heat transfer applications because of their non-Newtonian nature. Newton's law states that for a flowing viscous fluid, the force per unit area, or shear stress, required to maintain flow is proportional to the velocity gradient perpendicular to the direction of flow. In equation form (see end of article for notation),

$$F/A = \mu du/dx$$

or

$$\tau = \mu\gamma \qquad (1)$$

The proportionality constant, $\mu$, is commonly called the viscosity of the fluid and is given by the expression

$$\mu = \tau/\gamma \qquad (2)$$

Solutions of long chain molecules and suspensions do not in general obey this simple law. If measurements are made at different velocity gradients (shear rates), the ratio $\tau/\gamma$ will not be constant. This ratio is frequently called the apparent viscosity, $\mu_a$. Liquid fruit and vegetable products are usually in a class called pseudoplastic. These fluids are characterized by an apparent viscosity that decreases as the shear rate increases. It is a general observation that the behavior of pseudoplastic fluids can be fairly well represented by the equation

$$\tau = K\,\gamma^n \qquad (3)$$

$$\mu_a = \tau/\gamma = K\,\gamma^{n-1} \qquad (4)$$

The parameters K and n can be calculated from data obtained from a suitable coaxial cylinder viscometer. The shear stress on the stationary cylinder is observed as a function of shear rate by varying the speed of the rotating cylinder. If these data are plotted as $\tau$ vs $\gamma$ on logarithmic paper, the slope of the line is equal to n and the value of $\tau$ where $\gamma = 1.0$ is equal to K. It will be noted that if $n = 1.0$, $\mu_a = K$, and the fluid is Newtonian. If apparent viscosity decreases with increasing shear rate, n must lie between 1.0 and zero.

Another model frequently used to represent the behavior of these non-Newtonians is the so-called "Bingham plastic," which is characterized by a yield stress. At shear stresses lower than the yield value, the fluid will not flow. At higher stresses, shear stress is linear with shear rate. The equation representing this behavior may be written

$$\tau - \tau_y = m\gamma \qquad (5)$$

Figure 1 shows the type of behavior exhibited by Newtonians, Bingham plastics, and pseudoplastics on a plot of shear stress vs shear rate. It is unusual to find a fluid that is a true Bingham plastic, and most fluids which show a decrease in apparent viscosity with increasing shear rate conform more closely to Equation (4) than to Equation (5). In either case, two parameters are required to represent the behavior. It has long been recognized that single point constants, such as are obtained with consistometer or flow tube readings, cannot adequately describe the viscosity behavior of non-Newtonians. It would be entirely possible to have two products with the same consistometer reading but with quite different characteristics.

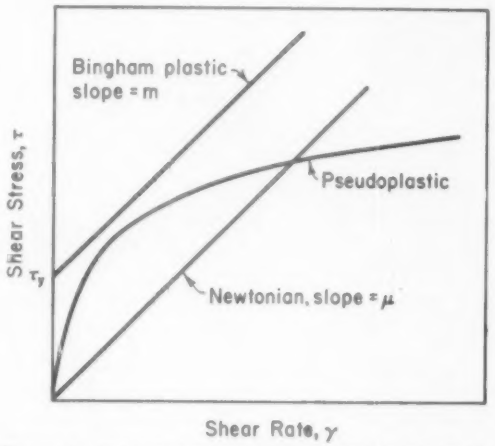



**Figure 1. Characteristics of some non-Newtonian fluids.**

In some materials, the property of thixotropy becomes important. A thixotropic fluid is one for which the shear stress is a function of time as well as shear rate. If present, this effect can be observed in a coaxial cylinder viscometer. At constant rotational speed, the shear stress will decrease with time to a steady state value. Otherwise, the behavior is similar to that of pseudoplastic fluids. An extensive treatment of non-Newtonian technology is presented in a review article by Metzner *(2)*.

This paper reports the results of an investigation of the performance of a wiped film evaporator in concentrating apricot, peach, and pear purees and a study on the viscosity characteristics of the products.

## EXPERIMENTAL

**Materials.** The materials used for this study were lots of single strength apricot, peach, and pear puree which had been hot filled into 5 gal cans. Specific information on the history of the raw materials and the details of processing were not available. Corn syrup was used as a feed material to obtain performance data with a Newtonian fluid.

**Evaporator.** The wiped film pilot scale evaporator is shown in Figure 2. The 12 in inside diameter by ¼ in wall thickness

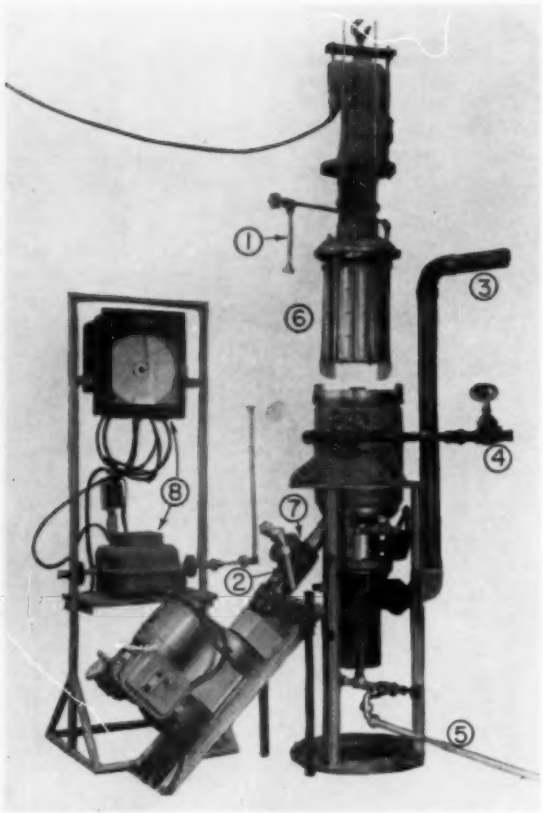



**Figure 2. View of disassembled evaporator. 1. Feed line. 2. Product line. 3. Vapor line to condenser. 4. Steam line. 5. Drain. 6. Rotor. 7. Product pump. 8. Magnetic flow meter.**

steam jacketed heating surface had an area of 4 sq ft. The rotor, which revolved at speeds up to 200 rpm, had 4 floating wiper bars constructed of reinforced Teflon. In the present work, only the maximum rotor speed of 200 rpm was used. Concentrated product was drawn from a well in the bottom, and vapor was drawn from the bottom through a discharge pipe to a condenser. Any liquid overflow was observed in a sight glass in the bottom section and could be pumped out. Concentrate was removed by a Moyno pump screwed directly into the discharge nozzle, as shown in Figure 2.

**Experimental procedure.** The feed was drawn by the evaporator vacuum from a container placed on platform scales. The total amount of feed for a run was determined by weight, and the magnetic flow meter (Figure 2) was used in conjunction with a manually operated valve to maintain a constant feed rate. Product and condensate were collected and weighed at the end of a run. Usually, a series of runs was made at one feed rate and with different jacket steam pressures. The following procedure was used:

1. Feed was started and the evaporator allowed to come to a steady state. The first run usually was with a low steam pressure.
2. Simultaneously, the weight on the feed scales was noted, containers were placed for the product and condensate, and a timer was started.
3. The run was usually terminated when 50 lb of feed had been introduced. At this point, the timer was stopped, and the product and condensate containers were withdrawn.
4. The steam pressure was set to a new value without interrupting the feed.
5. The product and condensate were weighed and samples collected. Samples were held at 32° F while awaiting viscosity and total solids determinations. The fact that viscosity measurements could be reproduced over extended periods of time indicated that the duration of storage did not affect the results.
6. Thermocouples were used to measure the evaporator inlet, product, and steam temperature. The feed material was at room temperature, which was substantially 70° F in these runs.

**Sample inspections.** Total solids were determined by oven drying for all fruit feed and product samples. Solids content of the corn syrup samples was obtained from refractometer readings. Viscosity measurements were made with a coaxial cylinder viscometer constructed in the Agricultural Engineering Department of the University. The design of this viscometer is similar to that used by Christiansen, Ryan, and Stevens *(1)*, but several improvements were incorporated. Basically, the viscometer is a narrow-gap instrument with provision for varying the speed of rotation of the outer cylinder over a wide range. Data presented in this paper were obtained by manually recording the torque on the inner cylinder as the speed of rotation of the outer cylinder was changed. The temperature was held at 80° F. A few Bostwick consistometer readings were made, although consistencies of the concentrates were usually so great that no Bostwick readings could be obtained. Because the purpose of these studies was to evaluate evaporator performance with respect to the fluid viscosities and because of the unknown history of the canned fruit puree used, other chemical and physical tests of interest in evaluating food quality were not made.

## RESULTS AND DISCUSSION

It was found possible to produce fruit concentrates of about 60% total solids. These concentrates have a consistency resembling that of a stiff grease and are far higher in concentration than can be produced with fruit purees in conventional vacuum pans. The limit on concentration lay in the ability of the high consistency product to flow down the evaporator and into the discharge nozzle. Heat damage appeared to be slight. A few qualitative comparisons between feed materials and samples of products reconstituted to the original concentration showed no apparent differences in color or taste. No viscosity measurements were made on samples reconstituted to the original concentration, so the extent of viscosity degradation is not known. Burn-on was insignificant except in localized areas where irregularities in the heating surface prevented good contact with the wiper blades. Minor modifications in the construction of the evaporator to improve product removal and wiper blade contact would undoubtedly permit going to higher concentrations.

Operating data, results of product inspections, and calculated heat transfer coefficient are given in Table 1. The viscosity parameters K and n were obtained from plots as shown in Figures 3, 4, and 5, for apricots, peaches, and pears, respectively. The data are plotted as $\mu_a$ vs $\gamma$, so that the slope of the line, as indicated by Equation (4), is equal to $n-1$. Thioxotropic effects in these materials were found to be negligible. Inspection of the figures shows that there is little variation in the slopes of the lines among all 3 products, indicating that the value of n is relatively constant. The difference among the various products is shown by the values of K. It may be inferred from

**TABLE 1**

**Evaporator performance**

| Run No | Rates lb/hr | | Total solids wt % | | Temperature °F | | Vac in hg | Viscosity | | Ht tr coeff |
|---|---|---|---|---|---|---|---|---|---|---|
| | Prod | Cond | Feed | Prod | Evap | Steam | | K | n | U* |
| | | | | | PEACH | | | | | |
| | | | | | | | | 9.4 | 0.44 | (Feed) |
| 1 | 36.3 | 108 | 10.9 | 40.1 | 101 | 234 | 27.8 | 585 | 0.35 | 219 |
| 2 | 25.5 | 118.5 | 10.9 | 49.8 | 105 | 274 | 27.8 | 855 | 0.34 | 188 |
| 3 | 29.3 | 114 | 10.9 | 49.6 | 108 | 303 | 27.7 | 1520 | 0.37 | 157 |
| 4 | 21.5 | 116.3 | 10.9 | 58.4 | 107 | 315 | 27.8 | 4400 | 0.34 | 150 |
| 5 | 272 | 135 | 10.9 | 17.0 | 102 | 232 | 27.8 | 13.8 | 0.55 | 294 |
| 6 | 189 | 186 | 10.9 | 21.9 | 106 | 268 | 27.6 | 21.1 | 0.55 | 315 |
| 7 | 159 | 211 | 10.9 | 26.0 | 111 | 294 | 27.5 | 134 | 0.40 | 316 |
| 8 | 138 | 229 | 10.9 | 29.6 | 116 | 314 | 27.4 | 180 | 0.40 | 316 |
| 9 | 61.6 | 165 | 10.9 | 37.5 | 111 | 311 | 27.7 | 440 | 0.38 | 223 |
| | | | | | PEAR | | | | | |
| | | | | | | | | 42.5 | 0.35 | (Feed) |
| 10 | 107 | 168 | 15.2 | 24.3 | 97 | 231 | 27.4 | 57.5 | 0.39 | 339 |
| 11 | 101 | 162 | 15.2 | 33.4 | 104 | 270 | 27.6 | 385 | 0.38 | 264 |
| 12 | 93 | 180 | 15.2 | 37.6 | 107 | 298 | 27.2 | 497 | 0.38 | 258 |
| 13 | 98.4 | 188 | 15.2 | 39.5 | 114 | 314 | 26.8 | 648 | 0.38 | 256 |
| 14 | 53 | 108 | 15.3 | 47.6 | 112 | 233 | 29.0 | 1200 | 0.33 | 242 |
| 15 | 47.9 | 112 | 15.3 | 51.3 | 113 | 268 | 29.0 | 2050 | 0.34 | 194 |
| 16 | 51 | 109 | 15.6 | 49.3 | 113 | 292 | 29.1 | 1700 | 0.34 | 165 |
| 17 | 51.6 | 107 | 15.6 | 48.8 | 115 | 313 | 29.1 | 1500 | 0.34 | 132 |
| | | | | | APRICOT | | | | | |
| | | | | | | | | 54 | 0.29 | (Feed) |
| 18 | 63.2 | 95.5 | 17.7 | 44.3 | 118 | 234 | 28.4 | 560 | 0.37 | 226 |
| 19 | 54.9 | 110 | 17.7 | 51.4 | 118 | 276 | 28.4 | 1080 | 0.36 | 190 |
| 20 | 42.7 | 112 | 17.7 | 55.2 | 118 | 297 | 28.5 | 1520 | 0.34 | 169 |
| 21 | 47 | 115 | 17.7 | 59.3 | 121 | 313 | 28.8 | 3000 | 0.32 | 163 |
| 22 | 63.4 | 92 | 16.7 | 41.4 | 120 | 236 | 27.8 | 540 | 0.35 | 219 |
| 23 | 17.7 | 46.2 | 16.7 | 55.4 | 191 | 239 | 15 | | | 293 |
| 24 | 108 | 24 | 16.7 | 23.0 | 169 | 239 | 15 | 112 | 0.35 | 159 |
| | | | | | CORN SYRUP | | | Viscosity centipoise | | |
| 25 | 47 | 116 | 14.0 | 48.4 | 89 | 234 | 28.4 | 5.3 | | 212 |
| 26 | 37 | 114 | 14.2 | 54.5 | 85 | 269 | 28.4 | 10.6 | | 164 |
| 27 | 23 | 119 | 14.2 | 63.6 | 87 | 292 | 28.4 | 33.8 | | 154 |
| 28 | 25 | 118 | 14.2 | 72.5 | 88 | 293 | 28.4 | 160 | | 153 |
| 29 | 134 | 141 | 14.8 | 29.6 | 80 | 231 | 28.0 | 20.5 | | 247 |
| 30 | 113 | 175 | 14.5 | 36.4 | 90 | 267 | 27.9 | 22.8 | | 262 |
| 31 | 96 | 183 | 14.3 | 40.8 | 92 | 294 | 27.7 | 29.0 | | 240 |
| 32 | 106 | 160 | 14.3 | 36.9 | 88 | 312 | 27.8 | 24.5 | | 189 |
| 33 | 87 | 170 | 15.1 | 41.5 | 112 | 313 | 27.2 | 22.8 | | 226 |
| 34 | 245 | 127 | 14.0 | 23.0 | 100 | 238 | 27.7 | 12.2 | | 245 |
| 35 | 214 | 169 | 14.3 | 25.0 | 92 | 270 | 27.6 | 14.6 | | 252 |
| 36 | 193 | 197 | 14.3 | 29.0 | 98 | 294 | 27.6 | 15.1 | | 262 |
| 37 | 159 | 210 | 14.0 | 31.0 | 105 | 309 | 27.5 | 14.9 | | 275 |
| 38 | 258 | 108 | 20.6 | 30.0 | 109 | 230 | 27.0 | 14.8 | | 239 |
| 39 | 208 | 156 | 21.1 | 36.2 | 110 | 265 | 26.9 | 18.6 | | 270 |
| 40 | 192 | 177 | 21.2 | 39.4 | 110 | 293 | 26.8 | 21.8 | | 259 |
| 41 | 186 | 189 | 21.2 | 42.0 | 112 | 310 | 26.8 | 24.0 | | 256 |
| | | | | | WATER | | | | | |
| 42 | 58 | 212 | | | 97 | 250 | 28.1 | 0.71 | | 360 |
| 43 | 72 | 243 | | | 100 | 275 | 27.9 | 0.68 | | 360 |
| 44 | 90 | 285 | | | 104 | 297 | 27.7 | 0.65 | | 380 |
| 45 | 114 | 321 | | | 107 | 313 | 27.5 | 0.63 | | 400 |

* U is over-all heat transfer coefficient, Btu/(hr)(ft²)(° F).

the discussion in the introduction that the value of n indicates the extent of departure from Newtonian behavior, whereas K is more nearly a measure of the viscosity or consistency. The small variation among values of n for the different products and concentrations accounts for the fact that single point consistency measurements can frequently be used with good results. As would be expected, the value of K increases in a regular manner with concentration. It is well known, however, that consistency (and therefore K) can be changed by various thermal, chemical, and mechanical actions, and it is not recommended that a quantitative relationship between K and concentration be defined until more is known about these latter effects. One measurement made at a temperature of 105° F, corresponding to a typical evaporator temperature, showed a decrease in viscosity of about 25% from the value at 80° F. Tabulated viscosities of the corn syrup were adjusted to correspond to the average evaporation temperature.

Heat transfer rates were calculated by making heat balances around the evaporator. The calculation requires a knowledge of specific heats of the feed and product materials. Calorimetric measurements showed that the specific heats are equal to within 1 or 2% to 1.0 minus one-half the weight fraction of total solids. Over-all heat transfer coefficients are based on the known heat transfer area and the difference between the steam and average evaporator temperature. The resistance to heat transfer in the stainless steel evaporator wall was about half the total resistance. An accurate measurement of the wall thickness could not be made, so that it was not possible to calculate dependable values of the inside film coefficients.

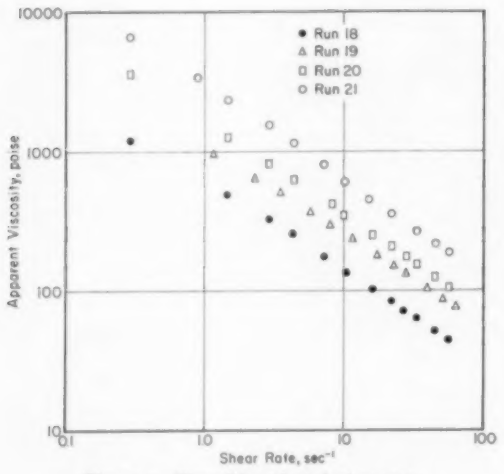



Figure 3. Viscosities of apricot purees.

It should be noted that local values of the inside film coefficient would be expected to show a marked decrease from the top to the bottom of the evaporator. At the top, the consistency of the fluid is low and the rate of evaporation high, and the coefficient should be high. At the bottom, the high consistency of the concentated product and the low rate of evaporation result in a low coefficient. The over-all coefficient for the evaporator averages the range of these extremes into a single value. In order to establish firmly the effect of concentration on heat transfer coefficient, a number of experimental runs would be required with only a small change in concentration, so that fluid properties would remain reasonably constant. Coefficients will also depend on the ratio of sensible to latent heat. Coefficients for heating are ordinarily substantially lower than for evaporating, so that higher evaporating temperatures for the same feed temperature will result in lower over-all coefficients. Other variables which might affect the coefficients but which were not specifically studied are feed rate, rotor speed,

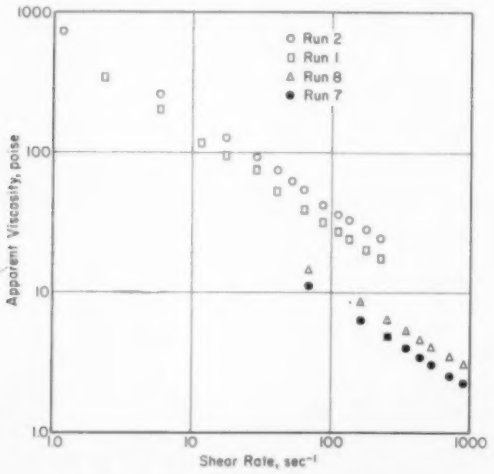



Figure 4. Viscosities of peach purees.

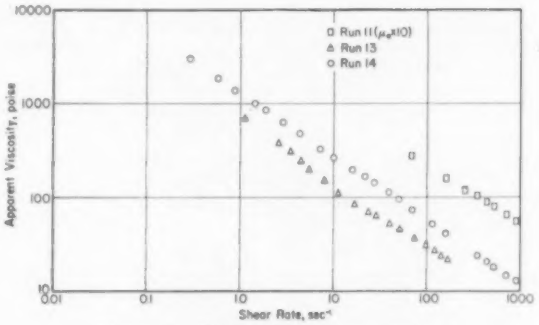



Figure 5. Viscosities of pear purees.

and the difference between steam and evaporator temperatures.

Despite the uncertainties caused by the effects discussed above, inspection of the tabulated data shows that the value of the over-all coefficient depends primarily on the value of K or $\mu$. Figure 6 is a plot of over-all coefficient against the average of the feed and product K values for the fruit runs. Figure 7 is a similar plot for the corn syrup and water data using average viscosity rather than K. Because the effect of temperature on the viscosities of the fruit materials is slight compared to the effect of concentration, deviations caused by failure to correct fruit viscosities to the evaporator temperature are well within the scatter of the data. In view of the various uncertainties, the correlations are remarkably good. An additional cause of scattering of the data is burn-on. In the last 4 pear runs listed in the table, the rate of evaporation did not change although the steam temperature progressively increased. Inspection of the evaporator showed a much larger than usual amount of burn-on. The effect of a high sensible heat requirement is shown by run 24, in which the feed had to be heated to 169° F for evaporation to begin. The coefficient falls significantly below the level of those plotted in Figure 6. The last two pear runs and the last apricot run are not plotted on Figure 6 because the deviations noted above would tend to obscure the results. The correlations shown in Figures 6 and 7 obviously are not sufficiently refined to serve as a firm

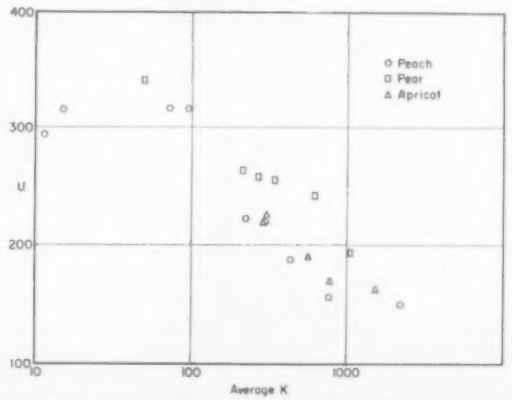
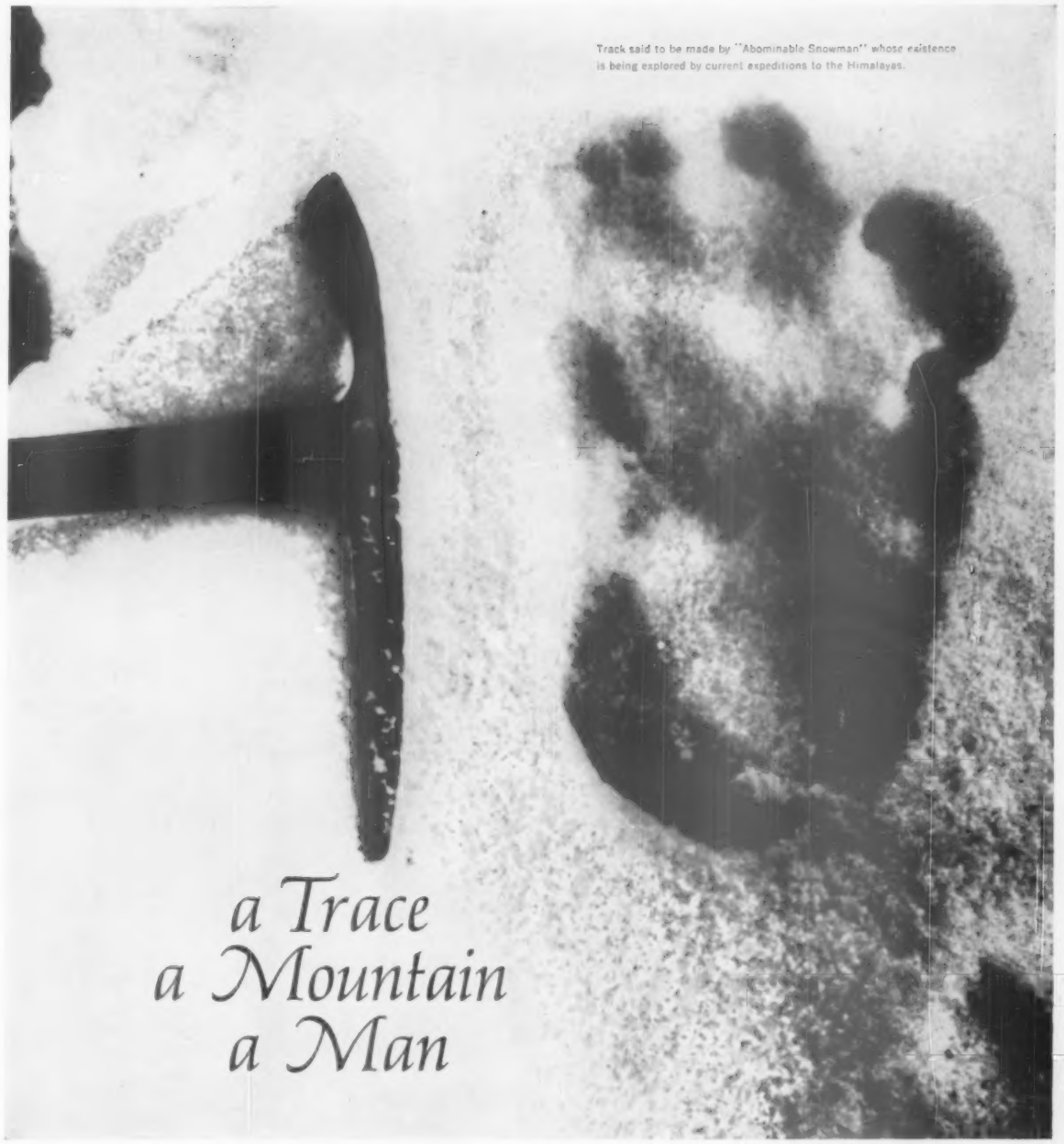



Figure 6. Over-all heat transfer coefficients with fruit purees.



Track said to be made by "Abominable Snowman" whose existence is being explored by current expeditions to the Himalayas.

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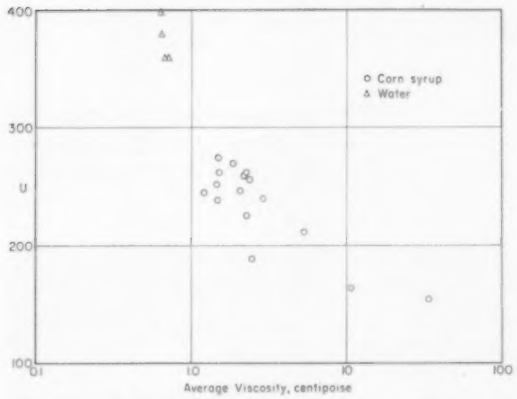


**Figure 7. Over-all heat transfer coefficients with corn syrup and water.**

engineering design basis. In the absence of more suitable correlations, however, they have considerable utility both in preliminary design and plant operation. In actual plant operations, normal variations in raw materials could be expected to cause greater changes in performance than are represented by the scattering of the data.

Because of the small variation in values of n, it was not possible to include the effect of this variable in the correlation. It is of interest, however, to compare the results shown in Figures 6 and 7. Corn syrup and water, being Newtonian fluids, correspond to n equal to 1.0. To put the two curves on the same basis, viscosity in Figure 7 should be divided by 100 to give units of poise instead of centipoise. On this basis, it is seen that the heat transfer coefficients are approximately the same for a ratio of K to $\mu$ of $10^4$, indicating that performance with a pronounced non-Newtonian is far superior to that of a Newtonian of the same apparent consistency. This result would be predicted from a knowledge of the viscosity behavior of the two type of fluids. One might expect roughly the same performance under conditions such that the apparent viscosities of the two fluids are equal. Consistencies are measured at very low shear rates, where the apparent viscosity of a pseudoplastic is high (see Figure 1), and the viscosity of a Newtonian would have to be very high to give the same consistency as the non-Newtonian. In the evaporator, where the material is being rapidly sheared by the wiper blades, conditions correspond to a point of low apparent viscosity of the pseudoplastic, and the viscosity of the equivalent Newtonian would be low. This result would not be observed in a conventional vacuum pan, where the material is not subjected to rapid shear.

## RECOMMENDATIONS

Much more work, both experimental and analytical, is obviously needed in order to establish the relationship of non-Newtonian characteristics of food materials to the design and operation of processes involving flow and heat transfer systems. Plant operators, particularly, should note the inadequacy of single point viscosity determinations to characterize these fluids in relation to equipment performance and should, wherever possible, obtain more complete viscosity measurements.

## SUMMARY

The performance of a wiped film evaporator in concentrating apricot, peach, and pear purees was investigated and the viscosity characteristics of the products established. It was found that the viscosity behavior was well represented by the equation

$$\tau = K\gamma^n$$

Over-all heat transfer coefficients correlated well with values of K, and performance was found to be much better for non-Newtonian fluids than for Newtonians of equivalent consistency.

### Acknowledgment

The author wishes to express appreciation to the Pfaudler Company for providing the evaporator used in these studies, to the Fischer and Porter Company for the magnetic flowmeter, to the Fairview Packing Company for providing the fruit purees, and to Sherman Leonard, B. S. Luh, and other staff members of the Food Science and Technology Department for their assistance in conducting the experimental work.

## NOTATION

| | |
|---|---|
| A | area, $cm^2$ |
| F | force, dynes |
| K, n | viscosity parameters for pseudoplastic fluid |
| m | "coefficient of rigidity" or "plastic viscosity" for Bingham plastic |
| u | velocity, cm/sec |
| U | over-all heat transfer coefficient, Btu/(hr)($ft^2$)(° F) |
| x | distance, cm |
| $\gamma$ | shear rate, du/dx, $sec^{-1}$ |
| $\mu$ | viscosity, centipoise |
| $\mu_a$ | apparent viscosity of non-Newtonian, centipoise or poise |
| $\tau$ | shear stress, dyne/$cm^2$ |
| $\tau_y$ | yield stress of Bingham plastic, dyne/$cm^2$ |

## LITERATURE CITED

1. Christiansen, E. B., Ryan, N. W., and Stevens, W. E. Pipe-line design for non-Newtonian fluids in streamline flow. *A.I.Ch.E. Journal*, 1, 544–48 (1955).
2. Metzner, A. B. Non-Newtonian technology. *Advances in Chemical Engineering*. Vol. 1. 1956. Academic Press, New York, N. Y.

# Evaluation of Instruments to Measure Firmness of Tomatoes[a]

(Manuscript received May 3, 1960)

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STUDIES OF THE objective determination of tomato firmness have been rather limited. Fischeer and Sengbush *(1)*, in 1935, measured firmness by placing the fruit under a cork attached to a fulerum. A weight was shifted along the fulerum until the tomato split. The readings were found to be affected by diameter of the fruit and the exact time of splitting was difficult to determine. In 1938, West and Snyder *(10)* used a Chatillion penetrometer and Paech *(9)* used a pressure tester to determine firmness of tomatoes. Changes in firmness of tomatoes with maturity were studied in 1944 by Lutz *(7)* using a pressure tester. The foregoing methods were either too slow or insufficiently accurate for practical use.

The first successful attempt to obtain objective measurement of tomato firmness similar to that as determined by hand was made in 1952 by Hamson *(3)*, who developed the Cornell pressure tester. Firmness was measured by the compression of a given weight at one point on the fruit. Of much interest are some more recent instruments. In 1957, Kattan *(4, 5)* reported the development of the Firm-o-meter, which is based on a multi-point-compression principle. McCollum *(8)* developed an instrument known as the McCollum Firmness Meter in 1957. In 1959, the Asco[d] Firmness Meter was commercially produced, the principle of operation being that developed by Kattan *(4, 5)*. The present study was conducted in order to evaluate the three latter instruments—the Firm-o-meter, the McCollum Firmness Meter, and the Asco Firmness Meter.

## MATERIALS AND METHODS

**McCollum Firmness Meter.** This instrument (Figure 1A) was constructed in this laboratory to measure firmness of tomato flesh as described by McCollum *(8)*. The procedure and mode of operation are as follows: The center slice, ½ in thick, is cut from the tomato and placed on a flat stainless steel plate. A glass container is placed on a plunger which is then placed in position on the tomato slice. A solenoid valve is opened by tripping a mercury switch, thus starting a flow of water into the container. When the combined weight of the water, container, and plunger punctures the flesh of the slice, the mercury switch automatically stops the flow of water. The more water in the container, the firmer the tomato flesh. The glass container is calibrated so that readings can be made to 0.2 of a unit, a unit being equal to 35 ml of water.

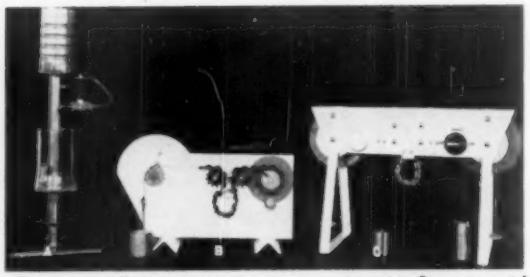

**Figure 1. Instruments to measure tomato firmness. 1A. McCollum firmness meter; 1B. Firm-o-meter. 1C. Asco firmness meter (Model 1).**

**Firm-o-meter.** This instrument (Figure 1B) used at Purdue, was made according to instructions provided by Kattan *(6)*. Instructions for its operation are detailed in *Arkansas Farm Research (5)* and in the *Proceedings* of the American Society of Horticultural Science *(4)*.

**Asco Firmness Meter (Model 1).** This instrument (Figure 1C) was designed on the same principle as the Firm-o-meter. The tomatoes are placed inside a loop of a specially designed chain as with the Firm-o-meter. A pre-stress weight of 1 kg is applied to the right end of the chain for 15 sec and then fixed in position by a friction brake. This also fixes the equivalent diameter dial so that this value can be recorded. A 1½ kg test weight is then applied for 15 sec to the left end of the chain by releasing a second friction brake.[e] This friction brake is then set to fix the firmness value in position. A mirror was used during these studies to insure that the fruit were placed uniformly in the instrument.

**Reproducibility of the Firm-o-meter and the Asco Firmness Meter.** In order to determine the reproducibility of measurement with the Firm-o-meter, firmness values were determined on 12 fruits. Firmness values were again determined on the same 12 fruits following random rearrangement. Reproducibility of the Asco Firmness Meter results was determined in the same manner but with different fruit.

**Comparison of instruments.** Individual fruits were harvested in varying stages of maturity and used to determine the relationship of firmness as determined by the various instruments. First, firmness values were obtained with one of the instruments. Then firmness values were again determined with a second instrument using the same fruits which had been randomly rearranged. All possible combinations of instruments were compared in this manner.

**Comparison of Asco firmness determinations with panel determinations.** Four groups of 10 tomatoes each were used. Groups were selected on the basis of the different ranges of firmness values as determined by the Asco Firmness Meter. Panel members were instructed to rank 4 fruits in order of firmness; one fruit from each of the 4 firmness groups mentioned above. The same fruits were then placed in storage at 15.5° C overnight and presented to the same panel members on the following day. The panel was unaware that they were being presented the same fruit for evaluation on the 2 consecutive days. To prevent undue firmness changes caused by handling, evaluation by the panel members of any one lot (set of 4 tomatoes) was limited to 2 judgments. A cloth covered platform was used to eliminate visual bias on the part of the panel mem-

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[d] Agricultural Specialty Company, Box 705, Hyattsville, Maryland.

[e] Modification of the instrument made at Purdue.

bers in making firmness judgments. Routine random placement of fruits under the platform was practiced in presenting any lot for panel evaluation.

## RESULTS AND DISCUSSION

**The reproducibility of the Firm-o-meter and the Asco Firmness Meter readings.** A highly significant correlation was found between firmness values obtained from 2 measurements on the same fruit as indicated by the data in Table 1. This relationship was found whether the Asco Firmness Meter or the Firm-o-meter was used. Of special significance when using the Firm-o-meter was the fact that extreme care had to be taken in the operation of this instrument to reduce human error. After the 2 firmness values were obtained on the same fruit with the Asco Firmness Meter, the second reading, in most instances, was smaller. This may be the result of cellular structure compression during the first measurement or to a greater amount of compression by the pre-stress weight during the second measurement. The reproducibility of the McCollum Firmness Meter could not be determined since the tomatoes were altered in the first measurement such that further firmness determinations could not be made.

TABLE 1

Reproducibility of the Asco Firmness Meter and the Firm-o-meter

| Fruit number | Asco firmness meter | | Firm-o-meter | |
|---|---|---|---|---|
| | Measurement 1 | Measurement 2 | Measurement 1 | Measurement 2 |
| 1 | 5.2 | 4.4 | 7.5 | 8.0 |
| 2 | 5.6 | 4.8 | 10.0 | 10.0 |
| 3 | 5.5 | 5.2 | 5.5 | 6.75 |
| 4 | 5.1 | 4.5 | 7.5 | 8.75 |
| 5 | 4.1 | 3.3 | 6.5 | 6.50 |
| 6 | 4.4 | 3.6 | 9.5 | 9.25 |
| 7 | 6.2 | 5.4 | 10.0 | 8.25 |
| 8 | 5.6 | 5.6 | 9.0 | 10.0 |
| 9 | 4.7 | 4.3 | 4.0 | 4.0 |
| 10 | 5.2 | 6.3 | 8.0 | 7.25 |
| 11 | 4.1 | 4.4 | 9.25 | 8.75 |
| 12 | 4.7 | 4.3 | 8.50 | 8.5 |
| Correlation coefficient | .743** | | .885** | |

** Significant at 1% level.

**Comparison of instruments:** The McCollum Firmness Meter was designed to measure the amount of force required to obtain a given amount of strain. The force, represented by the amount of water required to puncture the tomato slice, was then reported as the firmness of tomato flesh. The Firm-o-meter and the Asco Firmness Meter were designed to measure the amount of strain or compression resulting from the application of a given force. This compression, measured on a graduated scale, was then reported as the firmness of intact tomatoes. Firmness values determined with the Asco Firmness Meter were found to be independent from diameter *(2)*. The data in Table 2 illustrate the general relationship between fruit maturity and firmness as determined by the 3 instruments.

Firmness values obtained with the McCollum Firmness Meter were not correlated with firmness as measured by the Firm-o-meter (Table 3). However, a highly significant correlation was found between values obtained with the Asco Firmness Meter and the McCollum instrument. Firmness values determined by the Asco Firmness Meter and the Firm-o-meter were significantly related. Since the Asco Firmness Meter and the Firm-o-meter were designed on the same principle and are supposedly measuring the same factor, the 2 instruments would be expected to show the same relationship with values determined with the McCollum instrument.

TABLE 2

The general relationship between fruit maturity and firmness values*

| Visual fruit maturity | Firmness values | |
|---|---|---|
| | Asco and Firm-o-meter | McCollum |
| Green mature | 2.0– 4.0 | 15.0–30.0 |
| Ripe | 4.0– 8.0 | 5.0–15.0 |
| Over ripe | 8.0–10.0 | 0.0– 5.0 |

* The above values are general and do not indicate that all fruits in the different maturity classes would have firmness values in these ranges.

TABLE 3

Comparison of firmness as measured by the different instruments

| Instruments | Correlation Coefficient |
|---|---|
| McCollum Firmness Meter vs Firm-o-meter | —0.07 |
| McCollum Firmness Meter vs Asco Firmness Meter | —0.58** |
| Firm-o-meter vs Asco Firmness Meter | 0.72* |

* Significant at the 5% level.
** Significant at the 1% level.

The many improvements in addition to the basic design of the Firm-o-meter that have been incorporated into the Asco Firmness Meter may explain the above data. Firmness values could be read accurately to $\frac{1}{10}$ of a unit with the Asco Firmness Meter whereas the Firm-o-meter could be estimated only to the nearest $\frac{1}{4}$ of a unit. The fruit were pre-stressed with the Asco instrument to insure that all fruit were firmly in place before the test weight was applied. The Asco Firmness Meter also contains an automatic zero position which eliminates error that might be present in positioning the measurement pointer on the Firm-o-meter.

**Comparison of Asco firmness determinations with panel determinations.** The average agreement values (Table 4) were obtained by first determining the judgment error in relation to actual firmness values as determined by the Asco Firmness Meter. The judgment error was then converted into per cent agreement by proportionately relating this value to the total possible ranking error. The following example will illustrate the determination of judgment error and per cent agreement.

Example: Asco Firmness values and observer rankings

| Fruit number | Asco value | Difference between fruit | | | | Observer rank |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | |
| 1 | 3.40 | ..... | 1.60 | 1.85 | 5.75 | 1 |
| 2 | 5.00 | 1.60 | ..... | 0.25 | 4.15 | 3 |
| 3 | 5.25 | 1.85 | 0.25 | ..... | 3.90 | 2 |
| 4 | 9.15 | 5.75 | 4.15 | 3.90 | ..... | 4 |

**TABLE 4**

**The average percent agreement of panel firmness[1] evaluation with Asco firmness values**

| Set No | Firmness values Tomato No | | | | Average % agreement[2] | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Observer 1 | Observer 2 |
| 1 | 3.4 | 5.0 | 5.25 | 9.15 | 100.0 | 98.5 |
| 2 | 3.65 | 4.8 | 5.5 | 7.55 | 58.6 | 47.7 |
| 3 | 4.15 | 4.95 | 6.2 | 6.65 | 77.1 | 72.7 |
| 4 | 4.1 | 4.75 | 5.6 | 7.5 | 46.0 | 51.5 |
| 5 | 4.2 | 5.0 | 5.65 | 6.3 | 65.0 | 74.5 |
| 6 | 3.9 | 4.6 | 5.2 | 6.6 | 96.0 | 92.0 |
| 7 | 3.95 | 5.0 | 5.25 | 6.45 | 50.0 | 35.8 |
| 8 | 3.55 | 4.9 | 5.5 | 8.7 | 97.5 | 97.5 |
| 9 | 4.15 | 4.9 | 5.6 | 6.4 | 89.6 | 100.0 |

[1] Panel composed of 18 people, each person evaluating one set of 4 tomatoes with each set being evaluated by 2 people.

[2] The average % indicates the agreement of each observer with ranking of instrument. Each observer evaluated one set of fruit on 2 successive days.

*Determination of judgment error:*

1. Fruit number 1 was placed correctly over fruits number 2, 3, and 4. Thus, there was no error in judgment in the placement of this fruit.

2. Fruit number 3 was placed over fruit number 2, which does not agree with the instrument ranking. Therefore, a judgment error of 0.25 or the firmness difference between the 2 fruits is charged against the observer.

3. Fruit number 3 was placed correctly over number 4 and fruit number 2 was correctly placed over fruit number 4. Thus, no error in judgment is present in the placement of these fruits.

4. A total judgment error of 0.25 is charged against the observer as compared to the values determined by the Asco instrument.

*Determination of total possible error:*

1. The greatest possible error in placement of the fruit would be to completely reverse the order as determined by the instrument.

2. Under these conditions fruit number 4 would be placed incorrectly over fruits number 3, 2, and 1. The total error in placement of this fruit would be determined by adding the differences between fruit number 4 and each of the other fruits.

a. The difference between number 4 and number 1 is 5.75.
b. The difference between number 4 and number 2 is 4.15.
c. The difference between numbers 4 and 3 is 3.90.

3. The total error for placement of fruit number 3 was determined in the same manner.

a. The difference between numbers 3 and 2 is 0.25.
b. The difference between numbers 3 and 1 is 1.85.

4. The total error for placement of fruit number 2 was determined in the same manner.

a. The difference between numbers 2 and 1 is 1.60.

5. The total possible error for this set of fruit was then determined by addition of the differences.

a. 17.50.

*Determination of per cent agreement:*

1. The total possible error (17.50) minus the judgment error (0.25) gives the total points in agreement (17.25).

2. The points in agreement divided by the total possible error times 100 gives the per cent agreement. Thus, for this example, per cent agreement would be:

$$17.25 \div 17.50 \times 100 = 98.5\% \text{ agreement}$$

This method of evaluation is not ordinarily used and is presented here only to show that a majority of the sets of tomatoes were very accurately ranked by the observers. Although this was a very critical evaluation of ranked data, the lower agreement values could still be considered as acceptable. The data were also analyzed statistically using rank correlation procedures; they indicated a highly significant relationship between firmness rankings on the same fruit by different panel members. A highly significant rank correlation was also found between panel firmness evaluations and firmness values determined by the Asco Firmness Meter. Thus, the Asco Firmness Meter is apparently measuring firmness of tomatoes that simulates measurement by compression in the hand.

## SUMMARY AND CONCLUSIONS

The Firm-o-meter and the McCollum and Asco Firmness meters were evaluated. Data indicated that the Asco Firmness Meter was measuring firmness in the same manner as the Firm-o-meter. It was also found that the Asco Firmness Meter was measuring firmness in a manner similar to that determined by compressing the fruit in the hand. Flesh firmness of tomatoes as measured by the McCollum Firmness Meter was found to be correlated with firmness as measured by the Asco instrument.

It appears that the Asco Firmness Meter would be a valuable tool in the breeding program for fresh tomatoes as well as in a quality control program with fresh tomatoes. The McCollum Firmness Meter can be used as a tool in the selection of firm fleshed tomato varieties, but due to its characteristics, it could not be very handily used in a quality control program.

## LITERATURE CITED

1. Fischer, H., and Sengbush, R. Die Zuchtung von tomaten mit nicht platzenden and druckfesten. (The breeding of tomatoes with non splitting and pressure resistant fruits.) *Zucher*, **7**, 57–62 (1935). Cited by A. R. Hamson in Measuring firmness of tomatoes in a breeding program. *Proc. Am. Soc. Hort. Sci.*, **60**, 425 (1952).
2. Garrett, A. W. Problems in marketing fresh tomatoes. (M.S. thesis, Purdue University, 1960).
3. Hamson, A. R. Measuring firmness of tomatoes in a breeding program. *Proc. Am. Soc. Hort. Sci.*, **60**, 425 (1952).
4. Kattan, A. A. Changes in color and firmness during ripening of detached tomatoes, and the use of a new instrument for measuring firmness. *Proc. Am. Soc. Hort. Sci.*, **70**, 379 (1957).
5. Kattan, A. A. Firm-o-meter for measuring firmness in tomatoes. *Arkansas Agr. Exp. Farm Research*, **6**, 7 (1957).
6. Kattan, A. A. (Personal communications, 1958).
7. Lutz, J. M. Maturity and handling of green wrap tomatoes in Mississippi. United States Dept. Agr. *Cir. 695*, 1 (1944).
8. McCollum, J. P. (Personal communications, 1958).
9. Paech, K. Pflanzenphysiologische grundlagenforschung. *Landwirtsch. Jahrb.*, *85*, 653 (1938). Cited by A. R. Hamson in Measuring firmness of tomatoes in a breeding program. *Proc. Am. Soc. Hort. Sci.*, **60**, 425 (1952).
10. West, E. A., and Snyder, G. B. The effect of storage methods on ripening quality of tomatoes. *Proc. Am. Soc. Hort. Sci.*, **36**, 695 (1938).

# Emulsion Formation in Finely Comminuted Sausage

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(Manuscript received May 15, 1960)

SAUSAGE MAKING traditionally has been an art, and manufacturing procedures have been developed largely on an empirical basis. The knowledge and processes thus developed have made possible the production of excellent quality sausage under desirable conditions. However, when complications such as fat or water separation occur during processing, an inadequate understanding of the factors involved makes it difficult to select the proper corrective measures.

The first step in the manufacture of wieners consists of preparing a finely comminuted batter. The two main components of this batter are the muscle protein slurry and the subdivided fat particles. Wiener batter is therefore commonly referred to as an emulsion of fat globules in a continuous fluid protein phase. In subsequent heat processing the protein of the wiener is coagulated. If all goes well, the fat and water are retained, and a normal finished sausage results. However, there are times when fat and water separation occur during heat processing and the solution to this problem is not readily apparent.

One method for improving our understanding of sausage emulsions and their stability might be to examine samples microscopically. This was the approach taken in this study.

## METHODS

**Preparation and staining of sections.** Examination of a smooth, freshly cut wiener surface using a wide field microscope is not too revealing of tissue phenomena since no indication of structure is given. One sees only a moist, glistening surface containing some depressions due to air holes.

To be effective, microscopic examination of tissue requires the use of thin sections of the sample, sliced off by means of a microtome. A number of techniques are used by histologists to prepare tissue samples for sectioning, and for staining the sections when attached to a glass slide. One method requires complete dehydration of the sample with solvents, or by means of freeze drying, so that it can be embedded in paraffin and then sectioned. When used on wieners, however, these techniques resulted in samples that were so badly shrunken that their microscopic appearance could not be expected to portray accurately the original wiener structure.

The most satisfactory microtome slices were obtained using the frozen section technique. The wiener samples were fixed in formol saline *(3)* and sections 25 microns thick were cut off using a freezing microtome. Gelatine adhesive *(3)* was used for attaching the sections to glass microscope slides. Heidenhain's stain *(3)* gave a desirable differential staining of muscle and connective tissue in wiener batter: muscle protein was stained bright red while collagen was stained bright blue. However, in finished wieners the color differential was not as sharp since the muscle protein stained more purple.

Batter samples were hardened by first stuffing into a cellulose casing and then submerging in formol saline for a few days. The casing could then be peeled off and a sample cut from the rigid link for microtome sectioning.

**Staining of fat globule membrane.** Techniques have been developed for staining the protein membrane surrounding the fat globules in milk *(4)*. It was found that they could be applied to wiener batter if it was first diluted 1:5 with 7% NaCl solution and mixed at slow speed for 15 seconds in a Waring blender. Microscope slides dipped into the diluted batter were wiped clean on one side and then allowed to air dry. After fixing in ethyl alcohol and defatting with xylene, the protein residue was stained using an equal mixture of Ziehl's carbol-fuchsin and Loeffler's alkaline methylene blue *(6)* diluted with 3 parts of water.

**Separation of connective tissue from batter.** The method of Lampitt, Baker and Brown *(5)* was employed to separate connective tissue from batter samples. The total connective tissue after neutralizing and washing was spread out on a glass plate for photographing the actual size of the fragments.

**Preparation of emulsions using protein solutions.** A number of clear protein solutions were prepared and used to make emulsions in the laboratory. Water soluble proteins were extracted from beef and pork. Salt soluble proteins were extracted from fresh pre-rigor beef, post rigor beef, and pork, using 7% salt solution. Extractions were all made at 32° F (0° C) using moderate agitation for about 1 hr. The clear extract was separated by centrifugation and standardized to 2% protein.

Clarified pork fat was prepared by grinding mixed pork fatty tissue through a ⅛ in plate, warming it up to 130° F (54.4° C) with steam, centrifuging, and finally vacuum filtering through paper. The fat was chilled to 32° F (0° C) before use.

Emulsions were prepared using pre-chilled blender jars at 32° F (0° C). Two hundred ml of protein solution and 15 g of clarified pork fat were beaten together until a temperature of 60° F (15.6° C) was reached.

## RESULTS

**Appearance of batter at progressive intervals during a normal chopping process.** Samples of wiener batter were taken after 1, 5, 8, 10 and 12 min of chopping for microscopic observations. These were from a 700 lb production size batch chopped to 62° F (16.7° C) in 12 min. Photomicrographs of stained frozen sections taken at 50× are shown in Figure 1. The muscle fibers and fat cell walls are readily apparent in the initial stages of chopping. The fat cells are largely broken up in the first few minutes, but the muscle fibers are disintegrated more slowly.

The size and shape of connective tissue fragments was also checked at these intervals. They were observable as blue chunks in the above frozen sections. When observed microscopically, the pieces of connective tissue varied considerably in size and shape. To get a better idea of the actual particle size range, the connective tissue was separated from the batter and photographed. Figure 2 shows connective tissue after 1 min and after 12 min of chopping. These two samples are from the same chopping batch and contain the connective tissue from 10 g of batter. There appears to be very little, if any, size reduction of these tough pieces.

The batter samples taken at these progressive intervals were stuffed into cellulose casings and given a normal smoking and cooking process. Excessive fat separation took place in links when the batter had been chopped for only one minute. Batter chopped for 5 min held the fat better but some fat separation occurred. No fat separation occurred when wieners receiving 8, 10 and 12 min of chopping were smoked.

**Variation from standard chopping temperatures.** Figure 3 shows photomicrographs of stained frozen sections of wiener batter taken at 50×. These were from 13 lb batches produced,

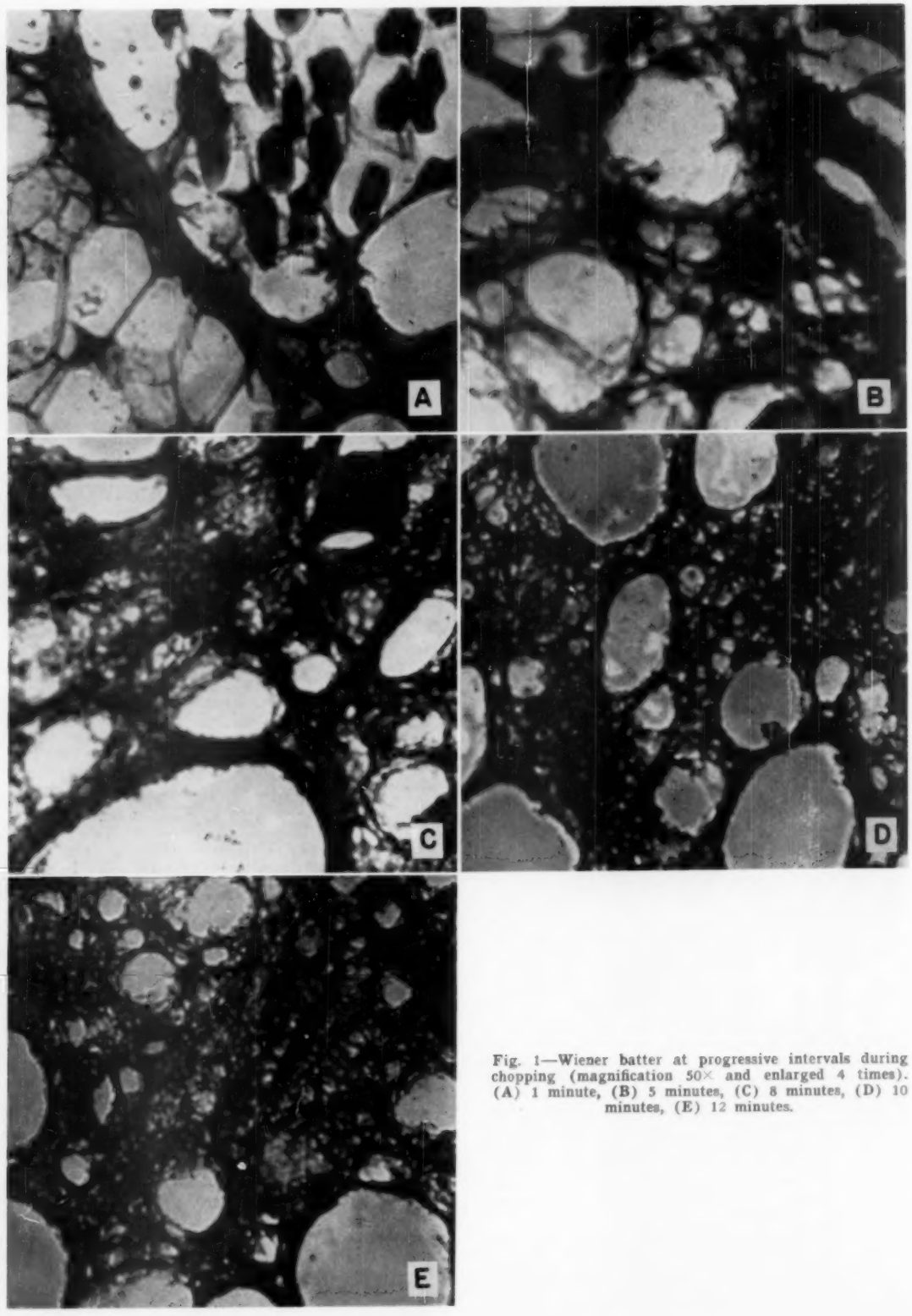



Fig. 1—Wiener batter at progressive intervals during chopping (magnification 50× and enlarged 4 times). (A) 1 minute, (B) 5 minutes, (C) 8 minutes, (D) 10 minutes, (E) 12 minutes.

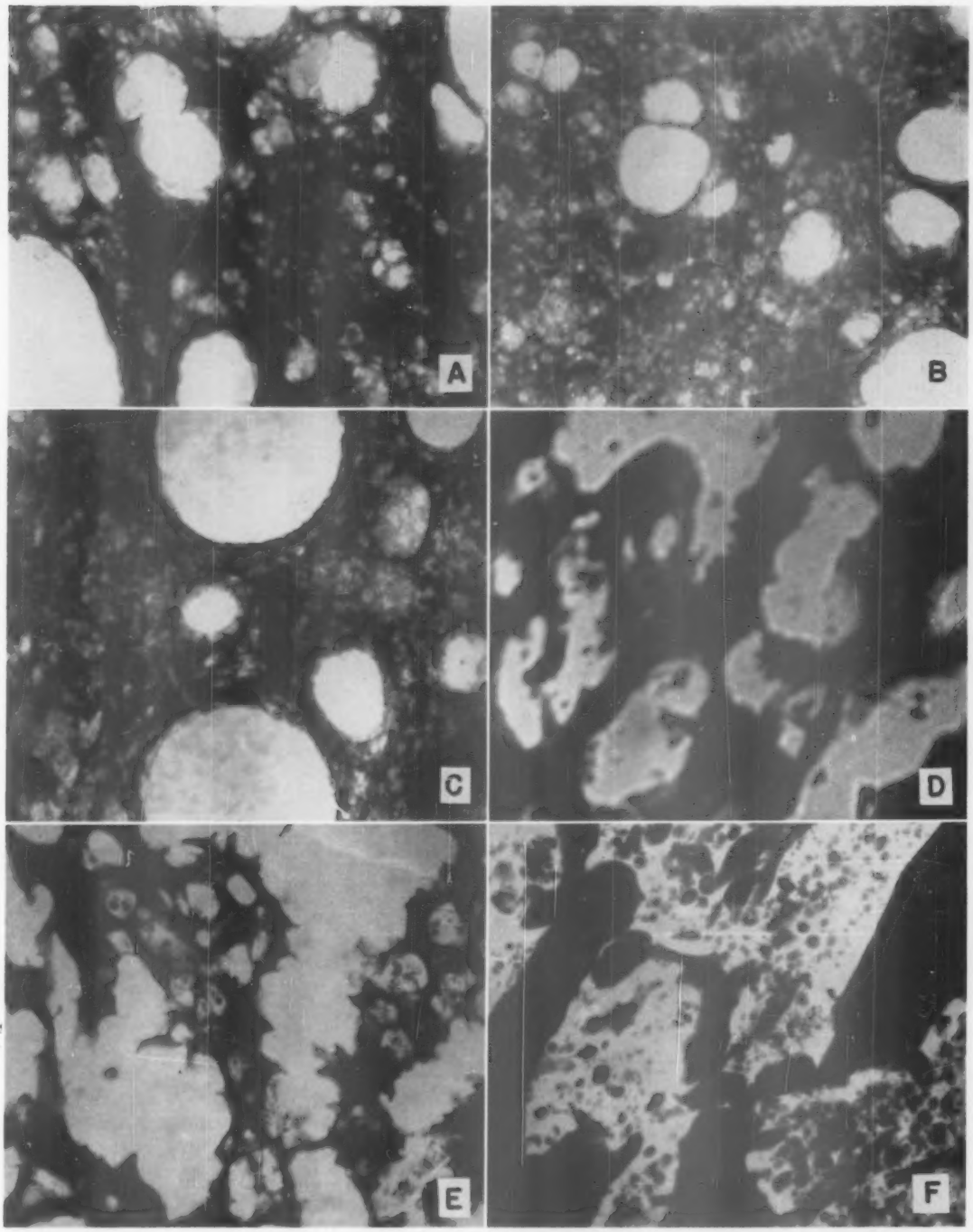



**Figure 3. Wiener batters chopped to various final temperatures (magnification 50× and enlarged 4 times). (A) 51° F (10.6° C), (B) 65° F (18.3° C), (C) 72° F (22.2° C), (D) 74° F (23.3° C), (E) 80° F (26.7° C), (F) 81° F (27.2° C).**

using a small experimental silent cutter. A number of time and temperature combinations were employed. Typical desirable appearing batters were obtained with final chopping temperatures of 51° F (10.6° C), 65° F (18.3° C) and 72° F (22.2° C). However, the fat globules in batter chopped to only 51° F (10.6° C) appeared to be somewhat larger. In each case, however, the disintegrated muscle protein formed a continuous matrix covering the individual fat globules.

Higher final chopping temperatures were obtained by using warm water instead of cold water and ice in the wiener formulation. Chopping to final batter temperatures of 74° F (23.3° C) and 80° F (26.7° C) resulted in the protein matrix

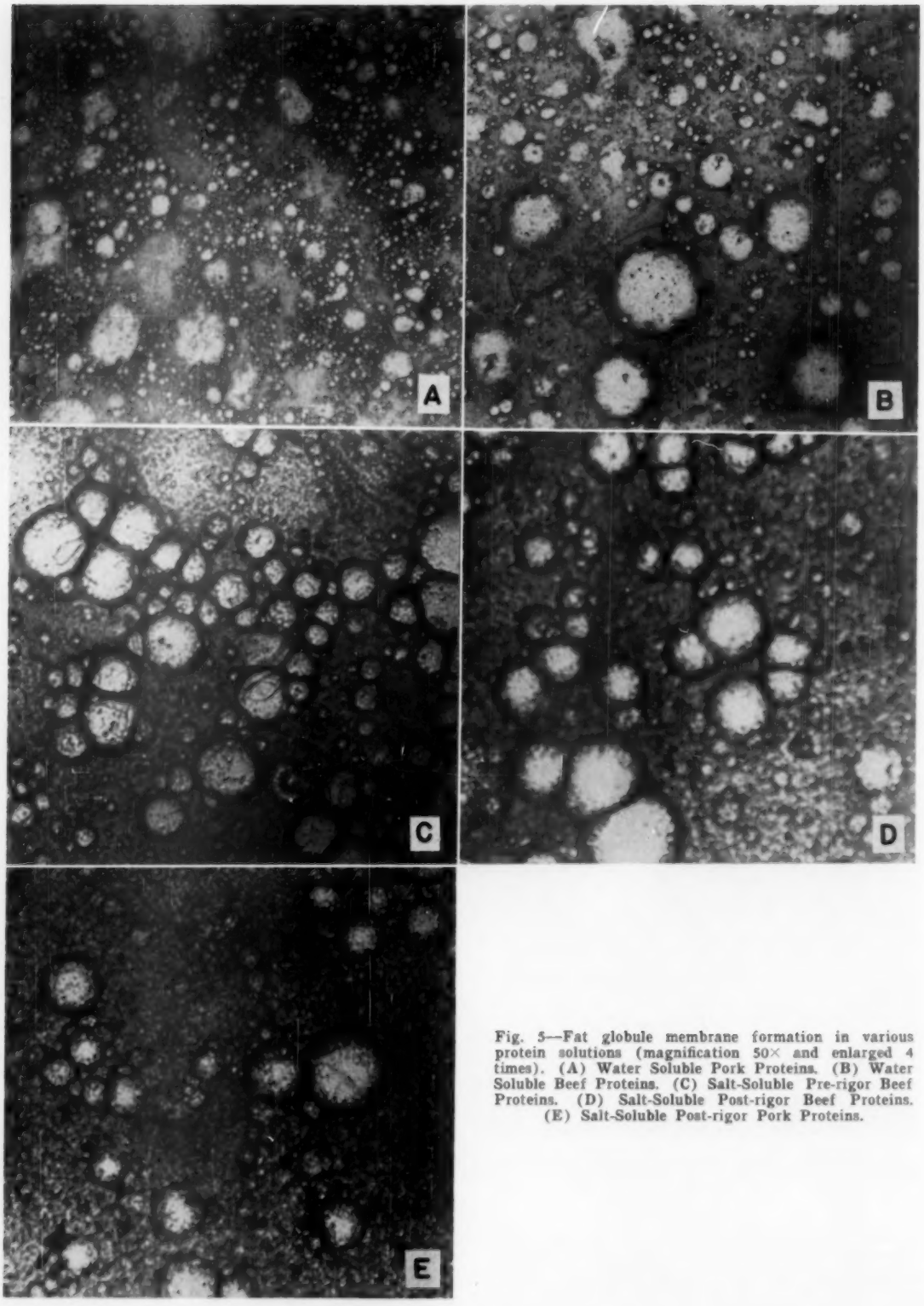
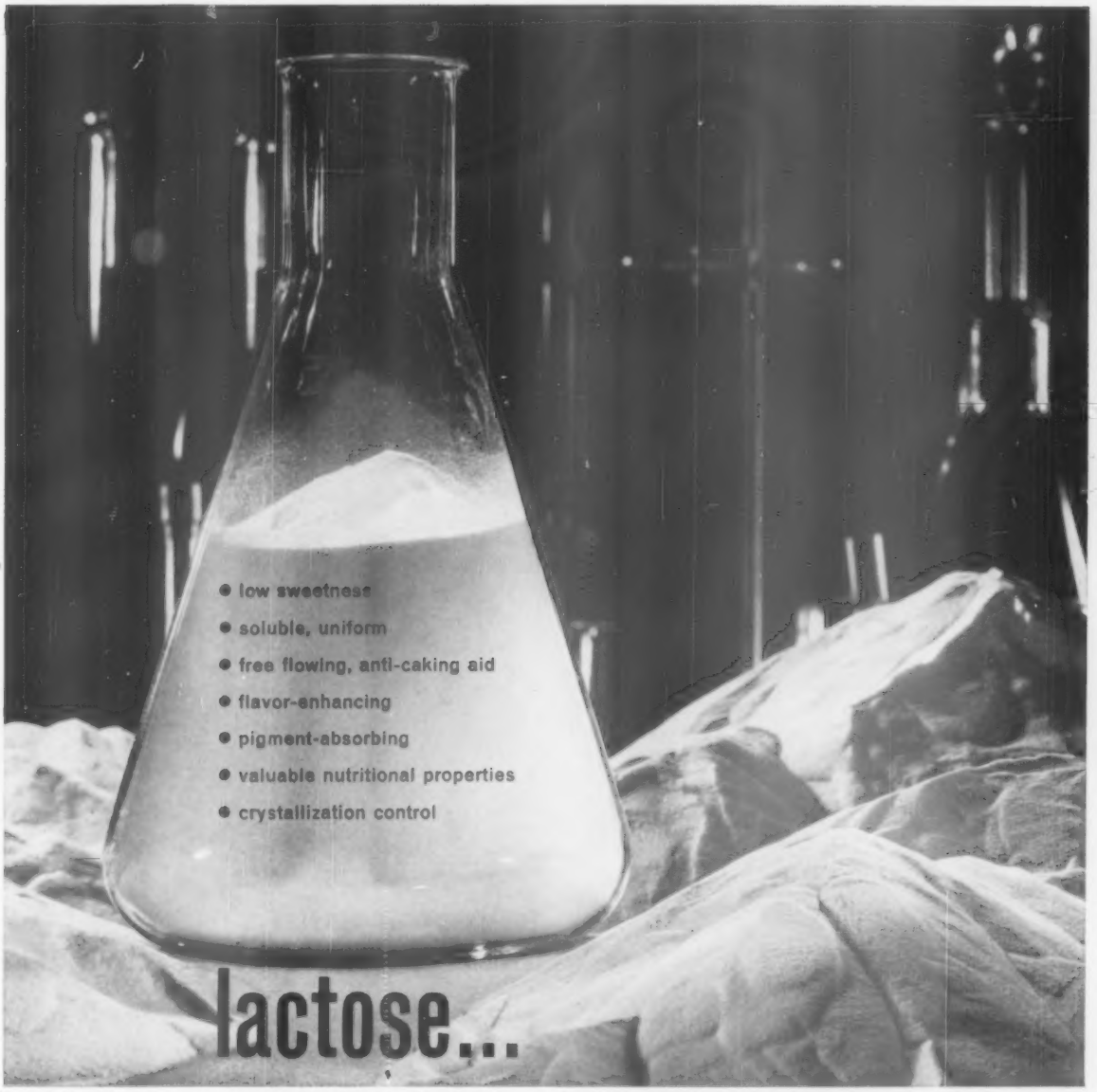



Fig. 5—Fat globule membrane formation in various protein solutions (magnification 50× and enlarged 4 times). (A) Water Soluble Pork Proteins. (B) Water Soluble Beef Proteins. (C) Salt-Soluble Pre-rigor Beef Proteins. (D) Salt-Soluble Post-rigor Beef Proteins. (E) Salt-Soluble Post-rigor Pork Proteins.

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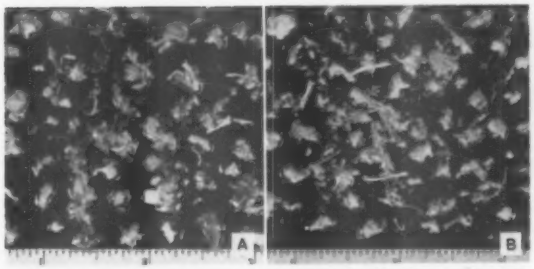


**Figure 2. Connective tissue in wiener batter before and after chopping. (A) Chopped 1 minute, (B) Chopped 12 minutes (Scale is in inches).**

being partially broken down. However, fat separation still did not occur when these wieners were smoked. The protein matrix was apparently still intact enough to lock the fat globules in place.

Chopping to final batter temperatures of 81° F (27.2° C) and higher resulted in completely breaking the protein matrix. When these wieners were smoked, extreme fat and water separation occurred.

**Presence of a fat globule membrane in wiener batter.** Figure 4 shows a typical photomicrograph of stained diluted wiener batter taken at 50×. This figure shows the concentration of protein to form an intact skin around the fat globules in wiener batter.

**Proteins which form the fat globule membrane.** Microscopic slides were also prepared of emulsions made in the laboratory, using various protein solutions and clarified pork fat. These were also examined under 50× magnification. The fat globules in the salt-soluble protein emulsions were covered with a thin, more deeply stained protein membrane. The fat globules in the water soluble protein preparations resulted in clear holes in the stained protein film. No concentration of protein was apparent at the fat globule surfaces. Photomicrographs showing these stained preparations are given in Figure 5.

## DISCUSSION

The above microscopic observations, made on stained frozen sections, give some insight into the formation of wieners. The chopping treatment breaks up and disperses the fat in the protein slurry to form an emulsion. This must be accomplished with sufficient temperature rise to partially soften the fat and facilitate its dispersion without getting a temperature so high that protein denaturation and breaking of the matrix begin to occur.

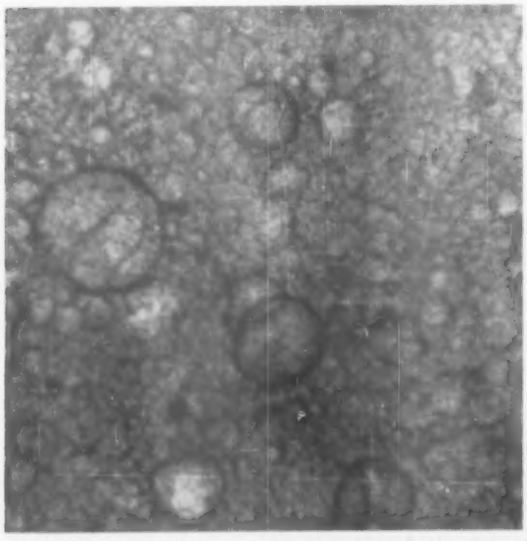

**Figure 4. Fat globule membrane in wiener batter (magnification 50× and enlarged 4 times).**

The presence of an emulsifying agent which will lower the interfacial tension and also form a strong protective membrane around the fat globules is usually regarded as the most important factor in preparing a stable concentrated emulsion *(1, 2)*. This film must have an affinity for the fat globule but be non-adherent to itself and thus prevent coalescence when globules collide. The emulsifying agent should be soluble in the continuous phase but must be drawn to the oil-water interface and adsorbed into a concentrated viscous rigid film. The concentration at the interface will then be considerably higher than in the bulk of the solution.

Stained preparations of diluted batter and also of emulsions, prepared by using clear protein solutions and clarified pork fat, indicate that such a fat globule membrane is formed in wiener batter. Since this membrane is formed only from salt soluble extracts, it appears to be composed, at least in part, of the salt soluble proteins myosin and actomyosin.

## SUMMARY

A dispersion of fat globules is formed within the protein slurry during chopping of finely comminuted sausage. The comparatively soft fat is broken up early in the comminution process but the globule size is reduced as chopping is continued. The muscle fibers that have a stronger structure than fat, constitute the component which determines the total chopping required. The fragments of tough connective tissue formed by preliminary grinding appear to remain unchanged during chopping of sausage emulsions.

Total chopping time must be sufficient to form a protein matrix enclosing the dispersed fat globules. The salt soluble proteins, myosin and actomyosin, appear to concentrate at the fat globule surfaces and form a stabilizing membrane.

If excessive temperature rise occurs during chopping, the protein matrix may be partially denatured and broken giving rise to an unprotected fat dispersion. This permits fat separation during smoking and cooking.

## LITERATURE CITED

1. Becher, P. *Emulsions: Theory and Practice.* 1957 Reinhold Publishing Corp., N. Y.
2. Bender, M. The colloidal state. *Am. Scientist,* **46,** 368 (1958).
3. Clayden, E. C. *Practical Section Cutting and Staining.* 3rd ed., 1955. J. & A. Churchill Ltd., London.
4. King, N. *The Milk Fat Globule Membrane.* 1955. Commonwealth Agricultural Bureau, Bucks, England.
5. Lampitt, L. H., Baker, L. C., and Brown, K. P. Connective tissue of meat. I. Separation and determination. *J. Sci. Food Agr.,* **3,** 367 (1952).
6. Society of American Bacteriologists, *Manual of Microbiological Methods.* 1957. McGraw-Hill Book Co., N. Y.

# Characteristics of Browning Enzymes in Fay Elberta Freestone Peaches[a]

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(Manuscript received May 16, 1960)

THE ENZYMATIC browning reaction in plant tissues may be divided into two distinct groups, referred to as "functional" browning and "adventitious" browning *(15)*. "Functional" browning occurs during normal development of the plant; "adventitious" browning follows cell damage. The latter is of prime importance in the commercial freezing of peaches since this process does not inactivate the enzymes responsible for the browning reaction. These oxidative enzymes, especially peroxidase *(1, 7)* and polyphenolase *(12, 14, 16, 17)* may cause browning not only during frozen storage, but also as the product is thawed.

The problem is serious because browning is generally accompanied by changes in color, flavor, and nutritive value, which greatly detract from the quality of the finished product *(8, 9, 11)*. Ascorbic acid content is reduced during discoloration of the fruit flesh. Adding L-ascorbic acid, which possesses antioxidant properties, is a convenient and practical means of retarding enzymatic browning in frozen peaches *(2, 3, 4, 20)*. The biologically inactive ascorbic acid isomer, D-isoascorbic acid, possesses antioxidant properties and has been shown to delay browning in frozen fruits *(6, 19, 21)*. Reports disagree as to the relative effectiveness of the two antioxidants.

Reported herein is an investigation of the characteristics and properties of peroxidase and polyphenolase in Fay Elberta freestone peaches. The effectiveness of L-ascorbic and D-isoascorbic acids are compared as antioxidants in enzyme-substrate model systems.

## EXPERIMENTAL MATERIALS AND METHODS

**Freestone peaches.** Fay Elberta freestone peaches were harvested at straw-yellow maturity at the University Farm, Davis, California on August 1, 1958. The fruits were ripened at 70° F until they reached an average pressure test (Magness-Taylor pressure tester, 7/16 in plunger) of 1–2 lb.

Forty ripe peaches were drawn at random for physical and chemical analysis. Another sample was washed, halved, pitted, and vacuum-sealed in polyethylene bags. The samples were frozen and stored at −15° F for investigations of enzyme activity.

**Extraction of enzymes.** For enzyme extraction, the peaches were removed from frozen storage, kept at 34° F for half an hour, peeled by hand, and cut into slices. Enzyme extraction was carried out at 34° F. One-hundred grams of peach tissue was blended for 2 min with 200 ml of 0.01 N acetate buffer at pH 5.6 in a Waring blender. The extract was centrifuged 20 min at 2200 rpm. The supernatant was decanted and mixed with 400 ml of acetone at −15° F. The enzyme precipitate-acetone mixture was allowed to stand for 5 min and then centrifuged 15 min at 2200 rpm. This supernatant was then decanted, and the precipitated enzyme was collected and suspended in 100 ml of 0.01 N acetate buffer at pH 5.6. The enzyme was reprecipitated with the addition of 200 ml of cold acetone and allowed to stand for 5 min. The mixture was again centrifuged 15 min at 2200 rpm, and the enzyme was suspended in 30 ml of 0.01 N acetate buffer at pH 5.6. The yellowish-beige preparation was centrifuged 30 min at 2400 rpm to remove debris. The enzyme preparation was kept in rubber-stoppered test tubes at 34° F. In some instances, several preparations were combined so that material would be sufficient for a given experiment.

**Polyphenolase activity.** Polyphenolase activity was measured by a modification of the colorimetric method described by Ponting and Joslyn *(18)*. All reactions were carried out in 500 ml Erlenmeyer flasks kept in a water bath at 30.0 ± 0.1° C. Enough 0.1 M citrate-0.2 M phosphate buffer at pH 6.0 was added to make a final reaction volume of 50 ml. After a known volume of catechol solution was added, the flask was swirled and allowed to reach temperature equilibrium. One ml of the enzyme preparation was added by a rapid-delivery pipette, and timing was begun. The flask was swirled slightly and allowed to remain in the water bath with no further agitation. At intervals of 1–3 min, depending on reaction rate, about 10 ml of the reaction mixture was pipetted out for absorbance reading in a Klett-Summerson photoelectric colorimeter equipped with a No. 42 blue filter. Distilled water was used as a blank to zero the colorimeter before measurement of enzyme activity. Klett readings were then plotted against time, and the slope of the straight line was used as a measure of enzyme activity.

The amounts of buffer and catechol solutions are not specified here since they depended on the experiment.

**Peroxidase activity.** The colorimetric method was also used for measuring peroxidase activity *(18)*. Guaiacol, in the presence of hydrogen peroxide, was used as the substrate instead of catechol. Since polyphenolase would not catalyze the oxidation of guaiacol, catechol, and guaiacol served as differential substrates, which made possible the measurement of only one enzyme activity at a time. All assays of peroxidase activity were performed in 0.1 M citrate-0.2 M phosphate buffer at pH 4.6. In all cases, the 50-ml reaction mixture contained 1 ml of enzyme and 1 ml of 0.086 N hydrogen peroxide. The amounts of guaiacol and buffer varied in the experiments.

**Optimum pH.** A study was made of the effect of pH on rate of catechol oxidation by polyphenolase and rate of guaiacol oxidation by peroxidase and hydrogen peroxide. Enzyme activities were determined in a citrate-phosphate buffer by the colorimetric method described above. For polyphenolase, the effect of pH was also studied in an 0.1 M oxalate-0.025 M phosphate buffer. In the final reaction mixture, the concentration was 0.03 M for catechol and 0.0029 M for guaiacol. The pH range for this series of experiments was 3 to 8. The optimum pH found for each enzyme in citrate-phosphate buffer was used throughout the remainder of these investigations.

**Substrate concentration.** Michaelis constants and maximum velocities for the two enzyme reactions were calculated from 1/activity plotted against 1/substrate concentration by the method of Lineweaver and Burk *(13)*.

**Hydrogen peroxide concentration.** Also determined was the effect of hydrogen peroxide concentration on guaiacol oxidation by peroxidase. The concentration of guaiacol in the reaction mixture was 0.0029 M, and the hydrogen peroxide concentration ranged from 0.00017 to 0.0173 N.

[a] Presented at the Twentieth Annual Meeting of the Institute of Food Technologists, San Francisco, California, May 16, 1960.

**Type of phenolic substrate.** The effect of phenolic substrate configuration on polyphenolase and peroxidase activity was also studied. The phenols compared were phenol, resorcinol, hydroquinone, and catechol. The ortho-, meta-, and para-dihydroxy configurations are all represented by these compounds. Phenol was included to serve as a monohydroxy substrate. The concentration of the above compounds in the 50-ml reaction volume was 0.10 M.

**Inhibitor studies.** Study was made of the inhibitory action of phloroglucinol, 1-phenyl-2-thiourea, and sodium diethyldithio carbamate on the rate of substrate darkening by polyphenolase and peroxidase. Catechol and guaiacol were used as substrates in respective concentrations of 0.040 and 0.043 M. Unless otherwise stated, the inhibitor compounds were used in concentrations of 0.03, 0.30, and 3.0 mM. The colorimetric method, with citrate-phosphate buffer at the respective pH optimum of each enzyme, was used to assay enzyme activity in the inhibitor studies.

**Effect of added antioxidant on polyphenolase and peroxidase activity.** Comparison was made of the efficiency of L-ascorbic and D-isoascorbic acids in retarding substrate darkening by polyphenolase and peroxidase. Reactions were carried out in a citrate-phosphate buffer with concentrations of 0.10 M catechol or 0.0073 M guaiacol. Only one antioxidant was used for each reaction. The amount of antioxidant added to the 50-ml. reaction volume was 1.7 to 5.1 $\mu$M for polyphenolase, and 0.85 to 3.4 $\mu$M for peroxidase.

## RESULTS AND DISCUSSION

**Effect of pH on peroxidase and polyphenolase activity.** Figure 1 shows the effect of pH on peroxidase activity as measured by rate of guaiacol darkening. With citrate-phosphate buffer, activity was optimum at pH 4.6 to 4.8. For polyphenolase, the optimum was at pH 5.9 to 6.3 (Figure 2). With oxalate-phosphate buffer, optimum pH was 6.5 to 6.8 for polyphenolase (Figure 3). The differing pH optima for polyphenolase with citrate-phosphate and oxalate-phosphate buffers indicate that enzyme activity may depend on the type of buffer as well as on pH.

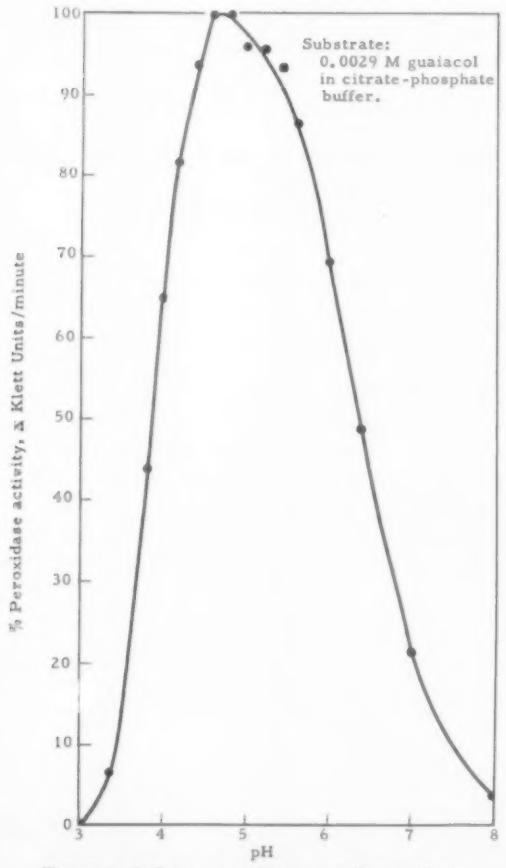


Figure 1. Influence of pH on peroxidase activity.

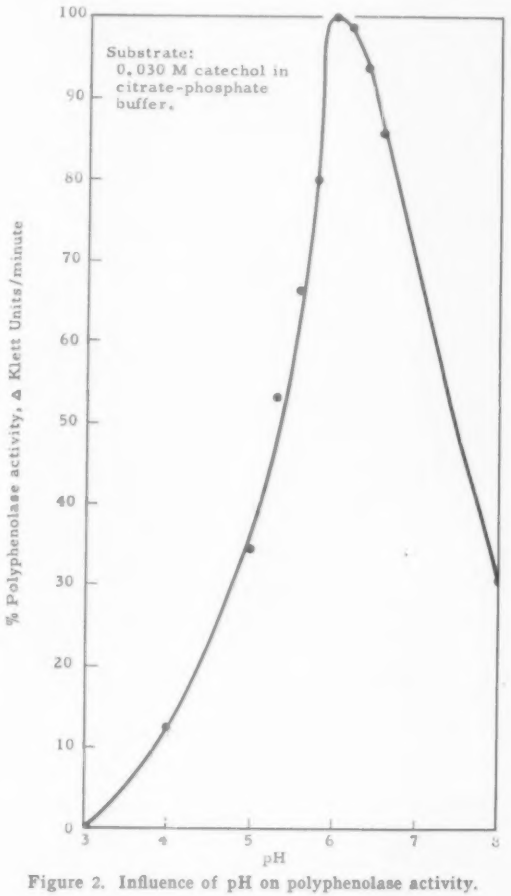


Figure 2. Influence of pH on polyphenolase activity.

At pH 3.8 in citrate-phosphate buffer, peroxidase activity predominated over polyphenolase activity. Peroxidase retained 41% of its maximum activity, whereas polyphenolase retained only 9%. Polyphenolase activity was absent at pH 3.8 in oxalate-phosphate buffer. Judging from the pH activity curve alone, peroxidase is probably the normal browning enzyme in peaches. Nevertheless, it is entirely possible that the environmental pH of the enzyme in the intact fruit may differ markedly from the pH of 3.8 in the macerated peach tissue. Therefore, assumptions on the role of the two enzymes in peach browning cannot be made from pH-activity data alone.

Measurement of enzyme activity by the colorimetric method may have its limitations. Since it is possible

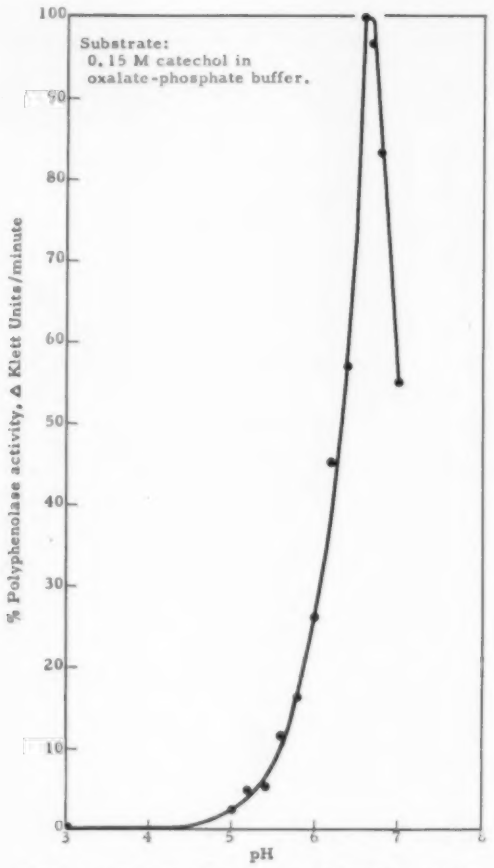


Figure 3. Influence of pH on polyphenolase activity.

that pigment formation and therefore rate of substrate darkening may depend on pH, intrinsic enzyme activity and darkening may not be directly proportional. The experiments reported above may therefore be best described as pertaining to the effect of pH on enzymatic rate of substrate darkening. The data are not thereby made unimportant, however, for it is fruit darkening rather than enzyme activity that concerns the fruit processing industry.

**Michaelis constants and maximum velocities.** Calculations of the Michaelis constants and maximum velocities of the two enzymes were based on data obtained by determining the effect of substrate concentration on enzyme activity. These data are shown in Table 1.

TABLE 1

**Michaelis constants and maximum velocity of polyphenolase and peroxidase from freestone peaches**

| Substrate | pH | Polyphenolase | | Peroxidase | |
|---|---|---|---|---|---|
| | | Michaelis constant | Maximum velocity, Δ Klett units per minute | Michaelis constant | Maximum velocity, Δ Klett units per minute |
| Catechol | 6.0 | 0.12M | 16.7 | ..... | ..... |
| Guaiacol | 4.6 | ..... | ..... | 0.010M | 37.0 |

Figures 4 and 5, respectively, represent the double reciprocal plots for polyphenolase and peroxidase. The Michaelis constant value was 0.12 M catechol for polyphenolase and 0.010 M guaiacol for peroxidase.

As seen in Table 1, maximum velocity is about twice as great for peroxidase as for polyphenolase. Maximum velocity is defined as the activity that occurs after the enzyme becomes saturated with substrate. The larger value expressed by peroxidase might mean that peroxidase was present in the enzyme preparation in larger quantities than was polyphenolase. But this is unlikely, since Ponting and Joslyn *(18)* reported that the ratio of peroxidase to polyphenolase was not over 0.3 in apple tissue and probably no greater in other fruits. A more likely explanation may be that peroxidase possesses a greater activity per unit enzyme than does polyphenolase. Further evidence of this has been supplied by Ponting and Joslyn *(18)* who found that the natural phenolic substrates in apple juice were oxidized more rapidly by peroxidase than by polyphenolase. This investigation produced similar results. On an equal substrate concentration basis, guaiacol darkening by peroxidase was approximately 6 times as fast as catechol darkening by polyphenolase. Thus, the larger maximum velocity shown by peroxidase is probably due to a greater activity per unit enzyme.

In accordance with enzyme kinetics, the following equation represents a typical enzyme reaction:

$$En + S \underset{K_2}{\overset{K_1}{\rightleftarrows}} EnS \xrightarrow{K_3} P + En$$

The Michaelis constant is a function of $K_1$, $K_2$, and

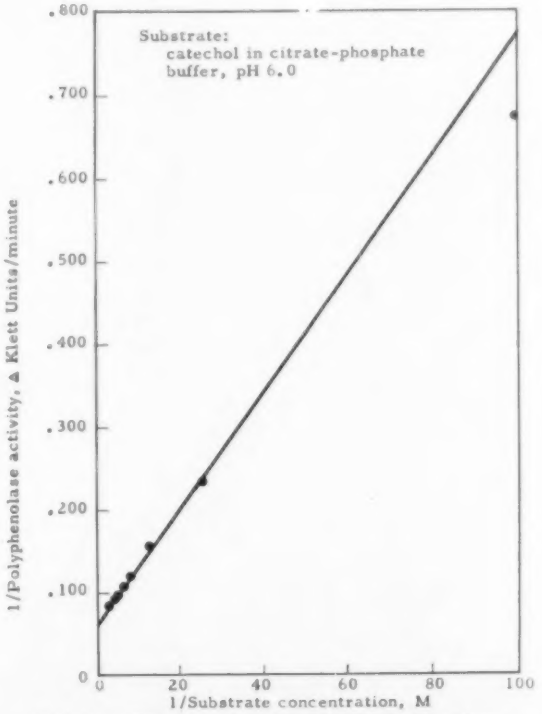


Figure 4. Double reciprocal plot for polyphenolase.

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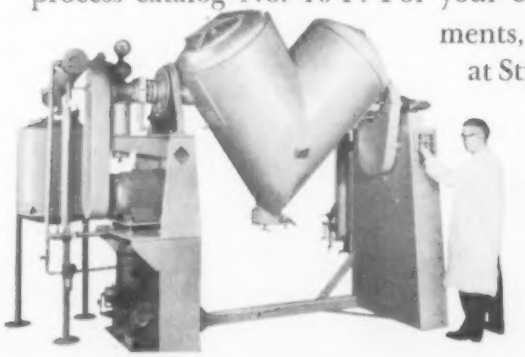

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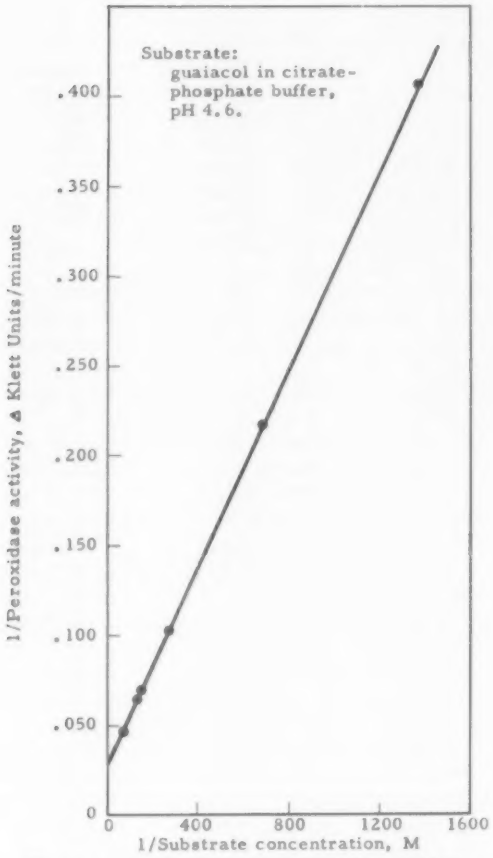


Figure 5. Double reciprocal plot for peroxidase.

$K_3$. The terms En, S, EnS, and P respectively refer to enzyme, substrate, enzyme substrate complex, and product. If it is assumed that the rate ($K_3$) of EnS breakdown to form the product (P) is small in relation to $K_1$ and $K_2$, the reported Michaelis constants involve only the ratio $K_2/K_1$. This ratio is the dissociation constant of the EnS complex and is inversely proportional to the affinity of the enzyme for its substrate. Since the Michaelis constant for peroxidase is $\frac{1}{10}$ that for polyphenolase (Table 1), it is inferred that peroxidase has an affinity for guaiacol about 10 times as great as that of polyphenolase for catechol. This may partially explain why the activity of peroxidase is greater than that of polyphenolase at equal substrate concentrations. It must be emphasized that the above explanation requires $K_3$ to be small in relation to $K_1$ and $K_2$.

**Effect of hydrogen peroxide concentration on peroxidase activity.** Figure 6 shows the effect of hydrogen peroxide concentration on peroxidase activity. A hydrogen peroxide concentration of 0.001 M to 0.004 M was necessary for maximum activity since inhibition occurred at higher concentrations while at lower concentrations the amount of hydrogen peroxide was insufficient to maintain maximum peroxidase activity. Thus, peroxidase cannot be important in peach browning if the concentration of hydrogen peroxide is insufficient. Ponting and Joslyn *(18)* showed conclusively that the darkening of apple tissue was largely due to polyphenolase, with peroxidase of minor importance. They found only small quantities of hydrogen peroxide in apples. The role of peroxidase in the browning of Fay Elberta peaches is therefore uncertain, even though its pH optimum favors it over polyphenolase as the normal enzyme causing browning.

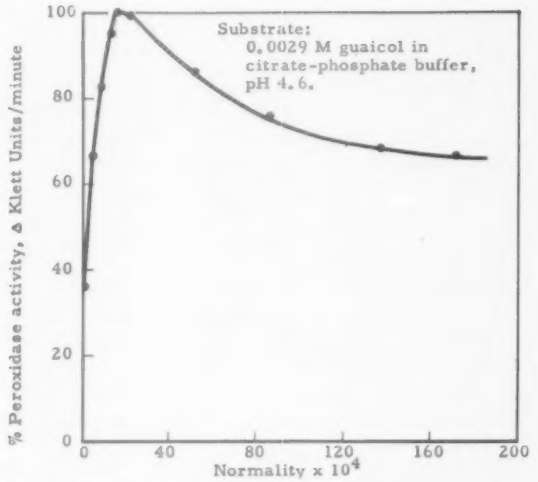


Figure 6. Influence of hydrogen peroxide concentration on peroxidase activity.

**Substrate specificity.** Table 2 shows the effect of phenolic substrate configuration on enzyme activity. The compounds chosen included the ortho-, meta-, and para-dihydroxy configurations, in addition to a monophenolic compound. Catechol, an ortho-dihydroxy compound, was oxidized by both enzymes at the same rate. Activity for polyphenolase was 5.50 Klett Units (K. U./minute) and the combined activity was 10.9 K.U./minute. Of all the compounds tested, the most rapidly oxidized was catechol.

TABLE 2

**Effect of phenolic substrate configuration on enzyme activity**

| Substrate (0.10M) | Enzyme activity, Δ Klett units per minute | |
|---|---|---|
| | Polyphenolase | Peroxidase + Polyphenolase |
| Phenol | 0.017 | 0.009 |
| Catechol | 5.50 | 10.9 |
| Resorcinol | 0.036 | 0.067 |
| Hydroquinone | 0.44 | 1.13 |

The para-dihydroxy compound, hydroquinone, was also oxidized by both enzymes, but very slowly. The rate for polyphenolase was 0.44 K.U./minute, while that for the combined enzymes was 1.13 K. U./minute. Thus, hydroquinone was oxidized approximately twice as fast by peroxidase as by polyphenolase. Neither enzyme exhibited significant activity with phenol or with the meta-dihydroxy compound, resorcinol, as substrates. The absence of activity with the last two

compounds, agrees with previous reports on the browning enzymes from apples *(18)*.

As mentioned in earlier sections, peroxidase was also found to oxidize guaiacol in the presence of hydrogen peroxide, whereas polyphenolase was unable to do so. Peroxidase from apples *(18)* has also been reported to catalyze the oxidation of both catechol and guaiacol. Polyphenolase from the same source, however, oxidized catechol but not guaiacol. In these respects, enzymes from apples were very similar to the peach enzymes reported here.

It appears that the primary reaction catalyzed by both polyphenolase and peroxidase, as extracted from the Fay Elberta freestone peach, is the oxidation of ortho-dihydroxy phenols. Peroxidase, in addition, can also catalyze the oxidation of phenols substituted in the ortho position with the methoxy grouping, as found in guaiacol. It is not implied, however, that the substrate specificity requirements are met by free phenols only, for it is known that phenols as such do not exist widely in nature *(11)*. Natural phenolic substrates are usually esterified with other constituents, such as sugars.

**Inhibitor studies.** Experiments were devised in an attempt to find a differential inhibitor for polyphenolase and peroxidase. It was hoped that incorporating the differential inhibitor in macerated peach tissue and measuring the rate of browning would determine the relative role of the two enzymes in peach browning.

Tables 3 and 4 present data on the effect of the various inhibitors on polyphenolase and peroxidase activity. Sodium diethyldithiocarbamate strongly inhibited both polyphenolase and peroxidase activity. Conversely, 1-phenyl-2-thiourea inhibited peroxidase less effectively than it did polyphenolase. These two compounds at concentrations of 0.3 mM reduced polyphenolase activity to 0 and 9% of its maximum, respectively. Peroxidase activity was similarly reduced, but only to 24.9 and 69.1% of its maximum, respectively. Both inhibitors are copper-chelating agents and would naturally be more effective in inhibiting the copper-containing polyphenolase *(5)*. Peroxidase, an enzyme containing iron, was also inhibited by these compounds because of the chemical similarities of copper and iron atoms.

TABLE 3

**Effect of various inhibitors on polyphenolase activity**

| Concentration m Molar | Polyphenolase activity,[1] Δ Klett units/minute | | | | | |
|---|---|---|---|---|---|---|
| | Sodium Diethyldithiocarbamate | | 1-Phenyl-2-thiourea | | Phloroglucinol | |
| | Activity | Residual activity, % | Activity | Residual activity, % | Activity | Residual activity, % |
| 0.0 | 3.13 | 100.0 | 3.13 | 100.0 | 3.13 | 100.0 |
| 0.03 | 2.77 | 88.5 | 2.03 | 64.0 | 2.66 | 85.0 |
| 0.3 | 0.0 | 0.0 | 0.28 | 9.0 | 2.55 | 81.5 |
| 3.0 | 0.0[2] | 0.0 | 0.0 | 0.0 | 1.01 | 32.3 |

[1] 0.040 m Molar catechol as substrate.

[2] Only 1.0 m Molar.

TABLE 4

**Effect of various inhibitors on peroxidase activity**

| Concentration m Molar | Peroxidase activity,[1] Δ Klett units/minute | | | | | |
|---|---|---|---|---|---|---|
| | Sodium Diethyldithiocarbamate | | 1-Phenyl-2-thiourea | | Phloroglucinol | |
| | Activity | Residual activity, % | Activity | Residual activity, % | Activity | Residual activity, % |
| 0.0 | 18.4 | 100.0 | 18.4 | 100.0 | 18.4 | 100.0 |
| 0.03 | 5.65 | 30.7 | 13.6 | 74.0 | 16.0 | 87.0 |
| 0.3 | 4.58 | 24.9 | 12.7 | 69.0 | 10.7 | 58.2 |
| 3.0 | 0.0[2] | 0.0 | 5.64 | 30.6 | 4.22 | 22.9 |

[1] 0.043 m Molar guaiacol as substrate.

[2] Only 1.0 m Molar.

In the concentration range used, phloroglucinol inhibited peroxidase more effectively than it did polyphenolase. With phloroglucinol in concentrations of 3.0, 0.3, and 0.03 mM, the respective residual activities were 32.3, 81.5 and 85.0% for polyphenolase, and only 22.9, 58.2 and 87.0% for peroxidase. This inhibitor does not possess copper-chelating properties but acts as a competitive inhibitor, since its structure is similar to that of the normal substrates. Inhibition of the darkening rate of polyphenolase and peroxidase by this metahydroxy compound is further evidence that both enzymes cannot oxidize the meta-hydroxy configuration.

As seen in Tables 3 and 4, no clear-cut differential inhibitor for the two enzymes was found. Therefore, no experiments could be carried out to elucidate the relative roles of polyphenolase and peroxidase in the browning of peach tissue. Data in Tables 3 and 4 show that only a slight differentiation was possible at the 0.3 mM sodium diethyldithiocarbamate level and at the 0.3 and 1.0 mM 1-phenyl-2-thiourea levels.

The presence of polyphenolase and peroxidase in peach tissue is evidenced by the sensitivity of the two enzymes to copper-chelating agents as well as by the information gathered from substrate specificity.

**Effect of added antioxidant on polyphenolase and peroxidase activity.** Table 5 shows the effect of added L-ascorbic and D-isoascorbic acids on polyphenolase and peroxidase activity. Both antioxidants retarded polyphenolase- and peroxidase-catalyzed darkening of substrates. Darkening was retarded in direct proportion to the amount of initially added antioxidant. The rate of darkening of catechol by polyphenolase—5.93 K.U per minute—was reduced to 2.64 K.U. by 5.1 $\mu$M of L-ascorbic acid, and 2.49 K. U. by 5.1 $\mu$M of D-isoascorbic acid. Similarly, the rate of darkening of guaiacol by peroxidase—20.1 K.U. per minute—was reduced to 9.5 K.U. by 3.4 $\mu$M of L-ascorbic acid,

TABLE 5

**Effect of added antioxidant on polyphenolase and peroxidase activity**

| $\mu$Moles Antioxidant per 50 ml reaction volume | Polyphenolase activity[1] | | $\mu$Moles Antioxidant per 50 ml reaction volume | Peroxidase activity[1] | |
|---|---|---|---|---|---|
| | L-Ascorbic acid | D-Isoascorbic acid | | L-Ascorbic acid | D-Isoascorbic acid |
| 0.0 | 5.93 | 5.93 | 0.0 | 20.1 | 20.1 |
| 1.7 | 5.54 | 5.16 | 0.85 | 16.9 | 17.0 |
| 3.4 | 4.23 | 4.23 | 1.7 | 14.1 | 15.0 |
| 5.1 | 2.64 | 2.49 | 3.4 | 9.5 | 9.8 |

[1] Expressed as Klett Units per minute.

and to 9.8 K.U. by 3.4 $\mu$M of D-isoascorbic acid. This effect may be due to traces of residual unoxidized antioxidant. Thus, if more antioxidant were added, the larger residual amounts would further inhibit rate of darkening. Another possibility is that the antioxidants inactivate or inhibit the enzymes in some manner. Ingraham *(10)* presented data demonstrating that the polyphenolase-catalyzed aerobic oxidation of catechol was not inhibited by ascorbic acid. He concluded that a slow reaction is possible between free polyphenolase and ascorbic acid, which does not occur when the enzyme is in the presence of catechol and oxygen. As the present experiments also were carried out in the presence of oxygen and catechol, no enzyme inhibition would be expected. Consequently, the effect of both antioxidants on rate of darkening (Table 5) can best be explained by the residual amounts of antioxidant.

The results indicate that the antioxidant properties of L-ascorbic and D-isoascorbic acids are very similar.

Oxidative darkening of phenolic substrates is now believed to proceed through polymerization of the quinone formed during the initial stages of the enzyme-catalyzed reaction. The antioxidants act by immediately reducing the quinone to the original ortho-dihydroxy form, thereby preventing polymerization and browning. Thus, these antioxidants do not act as true enzyme inhibitors, since enzyme activity continues, though without browning. Browning will not take place until nearly all of the antioxidant has been exhausted through oxidation by the enzyme. The time required for browning (induction period) will therefore be directly proportional to the amount of added antioxidants.

## SUMMARY

The characteristics and properties of polyphenolase and peroxidase from Fay Elberta peaches were investigated. These include the determination of optimum pH, Michaelis constant, and substrate specificity, as well as a study of chemical inhibition of enzyme activity.

A pH optimum of 4.6 to 4.8 in citrate-phosphate buffer, with guaiacol as substrate, was found for peroxidase. In the same buffer, polyphenolase with catechol as substrate, exhibited a pH optimum of 5.9 to 6.3. Michaelis constants of 0.12 M catechol and 0.010 M guaiacol are reported for polyphenolase and peroxidase, respectively. Both enzymes act primarily on the orthodihydroxy configuration. The paradihydroxy structure was also oxidized by both enzymes, but at a slower rate. Neither enzyme exhibited significant activity with the monohydroxy and metadihydroxy compounds as substrates.

Sodium diethyldithiocarbamate inhibited the activity of both polyphenolase and peroxidase. In contrast, 1-penyl-2-thiourea inihibited peroxidase less effectively than polyphenolase. Phloroglucinol, in the concentrations used, inhibited peroxidase more effectively than polyphenolase.

L-Ascorbic and D-isoascorbic acids were found to be equally effective as antioxidants.

## Acknowledgment

The authors thank the Campbell Soup Company for the fellowship that provided the financial assistance necessary for this work. We are also grateful to Chas. Pfizer and Company, Inc., for supplying the L-ascorbic and D-isoascorbic acid used in this investigation.

## LITERATURE CITED

1. Balls, A. K., and Hale, W. S. On peroxidase. *J. Biol. Chem.*, **107**, 767 (1943).
2. Bauernfeind, J. C., and Sieners, G. F. Retardation of discoloration in frozen sliced peaches by L-ascorbic acid. *Quick Frozen Foods*, **7**, 46 (1945).
3. Bauernfeind, J. C., and Sieners, G. F. Adding ascorbic acid to peaches before freezing. *Food Inds.*, **17**, 79 (1945).
4. DuBois, C. W., and Colvin, D. L. Loss of added vitamin C in the storage of frozen peaches. *Fruit Products J.*, **25**, 101 (1945).
5. DuBois, K. P., and Erway, W. F. Studies on the mechanism of action of thiourea and related compounds. Inhibition of oxidative enzymes and oxidations catalyzed by copper. *J. Biol. Chem.*, **165**, 711 (1946).
6. Esselen, W. B., Powers, J. J., and Woodward, R. D-Isoascorbic acid as an antioxidant. *Ind. Eng. Chem.*, **37**, 295 (1945).
7. Graubard, M. A comparative study of some oxidases and peroxidases. *Enzymologia*, **5**, 332 (1939).
8. Grice, M. A., Brown, N. D., and Burrell, R. C. Varietal characteristics influence browning of frozen peaches. *Food Eng.*, **24**, 131 (1952).
9. Guadagni, D. G., Sorber, D. G., and Wilber, J. S. Enzymatic oxidation of phenolic compounds in frozen peaches. *Food Technol.*, **3**, 359 (1949).
10. Ingraham, L. L. Effect of ascorbic acid on polyphenol oxidase. *J. Am. Chem. Soc.*, **78**, 5095 (1956).
11. Joslyn, M. A., and Ponting, J. D. Enzyme-catalyzed oxidative browning of fruit products. *Advances in Food Research*, **3**, 1 (1951).
12. Keilin, D., and Mann, T. Polyphenol oxidase: purification, nature, and properties. *Proc. Roy. Soc.* London **B125**, 187 (1938).
13. Lineweaver, H., and Burk, D. The determination of enzyme dissociation constants. *J. Am. Chem. Soc.*, **56**, 685 (1934).
14. Ludwig, B. J., and Nelson, J. M. Inactivation of tyrosinase in the oxidation of catechol. *J. Am. Chem. Soc.*, **61**, 2601 (1939).
15. Mason, H. S. Comparative biochemistry of the phenolase complex. *Advances in Enzymology*, **16**, 105 (1955).
16. Miller, W. H., and Dawson, C. R. A method for the measurement of tyrosinase and catecholase activity. *J. Am. Chem. Soc.*, **63**, 3375 (1941).
17. Nelson, J. M., and Dawson, C. R. Tyrosinase. *Advances in Enzymology*, **4**, 99 (1944).
18. Ponting, J. D., and Joslyn, M. A. Ascorbic acid oxidation and browning in apple tissue extracts. *Arch. Biochem.*, **19**, 47 (1948).
19. Schultz, K. E., and Schillinger, A. Oxidative decomposition of L-ascorbic acid. Comparison of the kinetics of non-fermentative oxidation of D-isoascorbic and L-ascorbic acids. *Z. Lebanan-Untersuch. u. Forsch.*, **94**, 77 (1952).
20. Woodroof, J. G. Ascorbic acid prevents frozen peaches from browning. Ga. Agr. Expt. Sta. Press *Bull. 567*, 1 (1946).
21. Yourga, F. J., Esselen, W. B., and Fellers, C. R. Some antioxidant properties of D-isoascorbic acid and its sodium salt. *Food Research*, **9**, 188 (1944).

# A Rapid Method for Determining Significance of Differences from Rank Sums[a, b]

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(Manuscript received May 17, 1960)

THE FOOD PROCESSOR is often faced with the problem of comparing his product with those of his competitors, or his new product with similar products already marketed by other firms. In other instances he may simply want to compare the quality of the same products as manufactured by different firms; or he may wish to evaluate the effect of certain process variables on the yield or quality of the finished product. In all such situations it is desirable to have a simple, rapid, and yet accurate means for determining whether the observed differences are real in terms of statistical significance, or whether they are due to mere chance variability.

This procedure is an expansion of one previously reported *(3);* it is especially suitable where actual values are not meaningful—for example, in evaluations of sensory data when, on occasion, it may be more convenient to rank series of samples in order of preference or difference. The method about to be described is based on the expansion of the multinomial distribution, using the treatment (t) designations as terms of the multinomial, and number of replications (r) as the power. The general expression is : $(t_1 + t_2 \ldots + t_n)^r$.

In this way the probability of the chance occurrence of a rank sum for any given treatment (sample) replicated r times, may be determined. Such calculated values are presented in Table 1 for the usual 5% level of significance (P = .05). The lower pair of values in each block are the smallest and largest rank sums such that the probability of *one* observed rank sum exceeding the larger entry, or of being exceeded by the lower entry, is less than or equal to 5%. Similarly, the upper pair of entries in each block are the smallest and largest rank sums such that the probability of *any* observed rank sum exceeding the larger entry or being exceeded by the smaller entry, is less than or equal to 5%. In Table 2, similar values are presented for the 1% level of significance (P = .01).

## CONDITIONS FOR USING THE LOWER ENTRIES DIRECTLY

Obviously the probability of detecting a significant difference when in fact one exists, is greater if the lower pairs of entries are used, particularly as *t* increases. The direct use of these values, however, should be limited to the following conditions *(2):*

(i) *t* treatments are ranked with ranks 1, 2 . . . t, in each of *r* replications

(ii) A particular treatment is picked *in advance* for consideration.

(iii) It may be assumed that the remaining (t-1) treatments do not differ, that is, are indistinguishable.

(iv) We test the null hypothesis that the specified treatment is also like the remaining set of indistinguishable treatments. This implies that it is equally likely that any treatment receives any of the ranks in each replication of the experiment.

(v) We use the rank total of the specified treatment as our test statistic and compare this observed rank total with the lower pair of entries in Table 1 for the suitable number of treatments and replicates.

**Example 1.** A beverage manufacturer has developed a new mixed fruit drink, which is to compete with a similar product already marketed by 3 other firms. Before beginning manufacture and distribution of this new product, the manufacturer wants some assurance that his product is superior, or at least not inferior to the competitive brands. He obtains random samples of the competitors' product, and submits them to a panel consisting of 10 individuals who are asked to rank the 4 coded samples (his product and that of the 3 competitors) in order of preference, with the following results:

| Panelists | Test sample $t_1$ | Competitive brands | | |
|---|---|---|---|---|
| | | $t_2$ | $t_3$ | $t_4$ |
| 1 | 4th | 1st | 2nd | 3rd |
| 2 | 4th | 3rd | 2nd | 1st |
| 3 | 3rd | 1st | 4th | 2nd |
| 4 | 3rd | 2nd | 4th | 1st |
| 5 | 4th | 1st | 3rd | 2nd |
| 6 | 2nd | 4th | 1st | 3rd |
| 7 | 4th | 2nd | 1st | 3rd |
| 8 | 3rd | 2nd | 4th | 1st |
| 9 | 4th | 1st | 3rd | 2nd |
| 10 | 2nd | 4th | 1st | 3rd |
| Rank sums | 33 | 21 | 25 | 21 |

Entering Table 1 for 4 treatments and 10 replications, we find the two lower entries are 19–31. Since the test sample rank sum of 33 exceeds 31, the manufacturer is justified in concluding that (vi) the 10 panelists have significantly rejected the test sample as being inferior in acceptability, since it was the least preferred compared to the other treatments.

Had another treatment yielded a rank sum in excess of 31 or less than 19, as for example, had treatment 2 resulted in a rank sum of 18 instead of 21, the manufacturer would not be justified in concluding that brand $t_2$ is preferred significantly, since this treatment was not selected in advance, and therefore violates condition (ii). Furthermore, the finding of two or more rank sums beyond the 19–31 limits would

[a] Scientific Art. No. A852, Contribution No. 3148, of the Maryland Agricultural Experiment Station (Department of Horticulture).

[b] Presented at the Twentieth Annual Meeting of the Institute of Food Technologists, San Francisco, California, May 18, 1960.

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raise some doubt on the validity of conclusion (vi), since there is now strong suspicion that the other treatments (i.e., $t_2$, $t_3$, $t_4$), are different, and thus condition (iii) would be violated.

## CONDITIONS NECESSITATING USE OF UPPER PAIR OF ENTRIES

If the manufacturer were interested in finding a superior sample, with the thought of producing a similar product, he would not be picking out a particular sample in advance, but merely examining the results of 4 samples with a view of selecting a superior sample, or rejecting an inferior sample. In this instance, the probability of the rank sum of any treatment being significant would be considerably higher, since there is now the opportunity of any one of the 4 treatments to be significant at the 5% level. In fact, if some 20 treatments were compared, there would not be a 5% probability ($P = .05$) for one of the treatments to be significant, but more like a 50% probability ($P = .50$). Thus, the upper pairs of values in each block of Table 1, reduce the power of selecting *any* treatment back to the 5% level. This is in line with multiple comparison procedures as discussed by Tukey *(4)*.

**Example 2.** Considering the same data as shown in example 1, but with no treatment specified in advance, we enter Table 1 for 4 treatments and 10 replications, and find the two upper entries are 17–33. Since none of these rank sums exceeds 33 or is exceeded by 17, we cannot conclude that any of these samples are superior or inferior. Had any sample yielded a rank sum of 34 or higher, then we would have been justified in rejecting that sample as inferior although we did not specify any particular sample in advance.

When a significantly different treatment is found, the remaining treatments may be reranked to determine if any further real differences exist.

**Example 3.** We have 4 samples ($t = 4$), each ranked by 10 panelists ($r = 10$), with the following results:

| Panelist | Samples | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 1 | 1 | 2 | 4 | 3 |
| 2 | 1 | 3 | 2 | 4 |
| 3 | 1 | 2 | 3 | 4 |
| 4 | 1 | 2 | 3 | 4 |
| 5 | 2 | 3 | 1 | 4 |
| 6 | 1 | 2 | 4 | 3 |
| 7 | 1 | 3 | 2 | 4 |
| 8 | 1 | 2 | 3 | 4 |
| 9 | 2 | 3 | 4 | 1 |
| 10 | 1 | 2 | 3 | 4 |
| Rank sums | 12 | 24 | 29 | 35 |

Not having specified any samples in advance, we enter Table 1, and find the upper pair of entries for 4 treatments and 10 replications are 17–33. Since the rank sum of sample 1 is less than 17, we select it as being superior. Sample 4, however, has a rank sum greater than 33, so that it may be considered inferior. We still have samples 2 and 3 about which we might wish to make a decision. We therefore re-rank samples 2 and 3, omitting samples 1 and 4, with the following results:

| Sample 2 | Sample 3 |
|---|---|
| 1 | 2 |
| 2 | 1 |
| 1 | 2 |
| 1 | 2 |
| 2 | 1 |
| 1 | 2 |
| 2 | 1 |
| 1 | 2 |
| 1 | 2 |
| 1 | 2 |
| 13 | 17 |

Entering Table 1 for 2 treatments and 10 replications we find the upper (and the lower) pair of entries 12–18. Since the rank sums of these samples are within the range of 12–18, we cannot conclude that samples 2 and 3 are different.

Any group of 2 or more samples may be compared in a similar manner.

**Significant interactions.** In taste testing work, the effect of the panelist may be of importance in two ways. Some panelists may evaluate all samples more leniently or more strictly than others. This problem is completely obviated when ranks are used, since the rank totals for each panelist must always be the same. Thus this "block" effect is automatically eliminated. However, the effect of the panelist may be in the form of an interaction between treatments and panelists. In other words, some individual panelist may rate certain samples high, while other panelists may rate them low. If this interaction, which may be of very practical importance, is considerable, it may even mask the differences among treatments.

There are two possible methods by which such interactions may be detected by the use of Tables 1 or 2: (1) by grouping of panelists on the basis of some logical criterion, and (2) by the use of replications for individual panelists.

**Example 4.** A panel is used to compare the acceptability of 5 ice cream formulations. The panel consists of 4 adults, and 4 children, with the following results:

| Panelists | Ice cream formulations | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Adults | | | | | |
| 1 | 1 | 5 | 3 | 2 | 4 |
| 2 | 2 | 3 | 1 | 4 | 5 |
| 3 | 1 | 4 | 3 | 5 | 2 |
| 4 | 1 | 2 | 5 | 4 | 3 |
| Adults rank sum | 5 | 14 | 12 | 15 | 14 |
| Children | | | | | |
| 5 | 4 | 1 | 3 | 2 | 5 |
| 6 | 5 | 1 | 2 | 4 | 3 |
| 7 | 1 | 2 | 5 | 4 | 3 |
| 8 | 3 | 1 | 4 | 5 | 2 |
| Children rank sum | 13 | 5 | 14 | 15 | 13 |
| Total rank sum | 18 | 19 | 26 | 30 | 27 |

**TABLE 1**

**Rank totals required for significance at the 5% Level (P=0.05)**

**The four figure blocks represent: Lowest significant rank sum, any treatment—Highest significant rank sum, any treatment. Lowest significant rank sum, predetermined treatment—Highest significant rank sum, predetermined treatment**

| Number of replicates | Number of treatments, or samples ranked | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 2 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | ..... | ..... | ..... | 3–9 | 3–11 | 3–13 | 4–14 | 4–16 | 4–18 | 5–19 | 5–21 |
| 3 | ..... | ..... | ..... | 4–14 | 4–17 | 4–20 | 4–23 | 5–25 | 5–28 | 5–31 | 5–34 |
| | ..... | 4–8 | 4–11 | 5–13 | 6–15 | 6–18 | 7–20 | 8–22 | 8–25 | 9–27 | 10–29 |
| 4 | ..... | 5–11 | 5–15 | 6–18 | 6–22 | 7–25 | 7–29 | 8–32 | 8–36 | 9–39 | 9–43 |
| | ..... | 5–11 | 6–14 | 7–17 | 8–20 | 9–23 | 10–26 | 11–29 | 13–31 | 14–34 | 15–37 |
| 5 | ..... | 6–14 | 7–18 | 8–22 | 9–26 | 9–31 | 10–35 | 11–39 | 12–43 | 12–48 | 13–52 |
| | 6–9 | 7–13 | 8–17 | 10–20 | 11–24 | 13–27 | 14–31 | 15–35 | 17–38 | 18–42 | 20–45 |
| 6 | 7–11 | 8–16 | 9–21 | 10–26 | 11–31 | 12–36 | 13–41 | 14–46 | 15–51 | 17–55 | 18–60 |
| | 7–11 | 9–15 | 10–20 | 12–24 | 14–28 | 16–32 | 18–36 | 19–41 | 21–45 | 23–49 | 25–53 |
| 7 | 8–13 | 10–18 | 11–24 | 12–30 | 14–35 | 15–41 | 17–46 | 18–52 | 19–58 | 21–63 | 22–69 |
| | 8–13 | 10–18 | 13–22 | 15–27 | 17–32 | 19–37 | 21–42 | 23–47 | 26–51 | 28–56 | 30–61 |
| 8 | 9–15 | 11–21 | 13–27 | 15–33 | 17–39 | 18–46 | 20–52 | 22–58 | 24–64 | 25–71 | 27–77 |
| | 10–14 | 12–20 | 15–25 | 17–31 | 20–36 | 22–42 | 25–47 | 27–53 | 30–58 | 33–63 | 35–69 |
| 9 | 11–16 | 13–23 | 15–30 | 17–37 | 19–44 | 21–51 | 24–57 | 25–65 | 28–71 | 30–78 | 32–85 |
| | 11–16 | 14–22 | 17–28 | 20–34 | 23–40 | 26–46 | 28–53 | 31–59 | 34–65 | 37–71 | 40–77 |
| 10 | 12–18 | 14–26 | 17–33 | 20–40 | 22–48 | 25–55 | 27–63 | 29–71 | 32–78 | 34–86 | 36–94 |
| | 12–18 | 15–25 | 19–31 | 22–38 | 25–45 | 29–51 | 32–58 | 35–65 | 39–71 | 42–78 | 45–85 |
| 11 | 13–20 | 16–28 | 19–36 | 22–44 | 25–52 | 28–60 | 31–68 | 33–77 | 36–85 | 39–93 | 41–102 |
| | 14–19 | 17–27 | 21–34 | 24–42 | 28–49 | 32–56 | 36–63 | 39–71 | 43–78 | 47–85 | 50–93 |
| 12 | 15–21 | 18–30 | 21–39 | 24–48 | 28–56 | 31–65 | 34–74 | 37–83 | 40–92 | 43–101 | 46–110 |
| | 15–21 | 19–29 | 23–37 | 27–45 | 31–53 | 35–61 | 39–69 | 43–77 | 47–85 | 51–93 | 55–101 |
| 13 | 16–23 | 19–33 | 23–42 | 27–51 | 30–61 | 34–70 | 37–80 | 41–89 | 44–99 | 48–108 | 51–118 |
| | 16–23 | 21–31 | 25–40 | 29–49 | 34–57 | 38–66 | 43–74 | 47–83 | 52–91 | 56–100 | 61–108 |
| 14 | 17–25 | 21–35 | 25–45 | 29–55 | 33–65 | 37–75 | 41–85 | 45–95 | 49–105 | 52–116 | 56–126 |
| | 18–24 | 22–34 | 27–43 | 32–52 | 37–61 | 41–71 | 46–80 | 51–89 | 56–98 | 61–107 | 66–116 |
| 15 | 19–26 | 23–37 | 27–48 | 32–58 | 36–69 | 40–80 | 44–91 | 49–101 | 53–112 | 57–123 | 61–134 |
| | 19–26 | 24–36 | 29–46 | 34–56 | 39–66 | 45–75 | 50–85 | 55–95 | 60–105 | 65–115 | 71–124 |
| 16 | 20–28 | 24–40 | 29–51 | 34–62 | 39–73 | 43–85 | 48–96 | 52–108 | 57–119 | 61–131 | 66–142 |
| | 20–28 | 26–38 | 31–49 | 37–59 | 42–70 | 48–80 | 53–91 | 59–101 | 65–111 | 70–122 | 76–132 |
| 17 | 21–30 | 26–42 | 31–54 | 36–66 | 41–78 | 46–90 | 51–102 | 56–114 | 61–126 | 66–138 | 71–150 |
| | 22–29 | 28–40 | 33–52 | 39–63 | 45–74 | 51–85 | 57–96 | 63–107 | 69–118 | 75–129 | 81–140 |
| 18 | 23–31 | 28–44 | 33–57 | 39–69 | 44–82 | 49–95 | 55–107 | 60–120 | 65–133 | 71–145 | 76–158 |
| | 23–31 | 29–43 | 35–55 | 42–66 | 48–78 | 54–90 | 60–102 | 67–113 | 73–125 | 80–136 | 86–148 |
| 19 | 24–33 | 29–47 | 35–60 | 41–73 | 47–86 | 53–99 | 58–113 | 64–126 | 70–139 | 76–152 | 81–166 |
| | 24–33 | 31–45 | 37–58 | 44–70 | 51–82 | 58–94 | 64–107 | 71–119 | 78–131 | 84–144 | 91–156 |
| 20 | 25–35 | 31–49 | 37–63 | 43–77 | 49–91 | 55–105 | 61–119 | 67–133 | 73–147 | 79–161 | 85–175 |
| | 25–35 | 32–48 | 39–61 | 46–74 | 54–86 | 61–99 | 67–113 | 74–126 | 82–138 | 89–151 | 96–164 |

If we should compare the total rank sums against the upper values in Table 1 for 5 treatments and 8 replications we would find that none of these rank sums exceed 33, or are smaller than 15, and we might conclude that we had not succeeded in demonstrating any significant preference for a particular ice cream sample. However, if we examine the rank sums for adults and children separately, we find a significant preference for sample 1 among the adults, since the rank sum of 5 for adults is less than the required 6 obtained from Table 1. Similarly it may be concluded that the children preferred sample 2.

If individual panel ratings were replicated, that is, if each panelist were required to rate each sample more than once, then each panelist's or each group of panelists' results could be summed separately and compared to the proper entries in Tables 1, or 2.

### Sequential applications

Table 1 may be used conveniently to interpret data from sequential experiments, such as those suggested by Box for evolutionary operations *(1)*. Thus, series of tests may be repeated, and the rank sums increased until a significant result is achieved.

**Example 5.** Time and temperature of blanch has an effect on the extent of sloughing of green beans. Five treatments are tried, successively, with the following results:

| Series | Blanching treatments (t) | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Replications | 2 minutes at 180°F | 2 minutes at 200°F | 3 minutes at 190°F | 4 minutes at 180°F | 4 minutes at 200°F |
| 1 | 3rd | 2nd | 1st | 5th | 4th |
| 2 | 2nd | 1st | 3rd | 4th | 5th |
| 3 | 3rd | 1st | 4th | 5th | 2nd |
| Rank sum for Rep's 1–3 | 8 | 4 | 8 | 14 | 11 |
| 4 | 3rd | 2nd | 1st | 4th | 5th |
| 5 | 2nd | 1st | 4th | 3rd | 5th |
| 6 | 4th | 2nd | 1st | 5th | 3rd |
| Rank sum for Rep's 4–6 | 9 | 5 | 6 | 12 | 13 |
| Accumulative Rank sum for Rep's 1–6 | 17 | 9 | 14 | 26 | 24 |

With 5 treatments, a minimum of 3 replications would be required to reach any definite decision (Table 1). At the conclusion of the third series, however, no rank sum exceeded 14 or was exceeded by 4 (4–14 being the entries in Table 1 for 5 treatments and 3 replications), thus necessitating additional replication. At the conclusion of 3 additional series, however, the rank sum of 9 for treatment 2 could be considered significant at the 5% level, and the experiment could now move in that direction, that is, shorter time, and/or higher temperature of blanch.

### How the tables are prepared

Having $t$ treatments and $r$ replications, the lowest possible rank sum for a given treatment would be equal to $r$, and the largest possible rank sum would be equal to $tr$. Thus, for example, for 5 treatments replicated 8 times, the smallest rank sum would be $r = 8$, and the largest would be $tr = (5)\ (8) = 40$. The total number of possible permutations may be expressed as the number of treatments to the power

**TABLE 2**

**Rank totals required for significance at the 1% level (P=0.01)**

**Each block of four represents: Lowest significant rank sum, any treatment—Highest significant rank sum, any treatment. Lowest significant rank sum, predetermined treatment—Highest significant rank sum, predetermined treatment**

| Number of replicates | Number of treatments, or samples ranked | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 2 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 3–19 | 3–21 | 3–23 |
| 3 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 4–29 | 4–32 | 4–35 |
| | ..... | ..... | ..... | 4–14 | 4–17 | 4–20 | 5–22 | 5–25 | 6–27 | 6–30 | 6–33 |
| 4 | ..... | ..... | ..... | 5–19 | 5–23 | 5–27 | 6–30 | 6–34 | 6–38 | 6–42 | 7–45 |
| | ..... | ..... | 5–15 | 6–18 | 6–22 | 7–25 | 8–28 | 8–32 | 9–35 | 10–38 | 10–42 |
| 5 | ..... | ..... | 6–19 | 7–23 | 7–28 | 8–32 | 8–37 | 9–41 | 9–46 | 10–50 | 10–55 |
| | ..... | 6–14 | 7–18 | 8–22 | 9–26 | 10–30 | 11–34 | 12–38 | 13–42 | 14–46 | 15–50 |
| 6 | ..... | 7–17 | 8–22 | 9–27 | 9–33 | 10–38 | 11–43 | 12–48 | 13–53 | 13–59 | 14–64 |
| | ..... | 8–16 | 9–21 | 10–26 | 12–30 | 13–35 | 14–40 | 16–44 | 17–49 | 18–54 | 20–58 |
| 7 | ..... | 8–20 | 10–25 | 11–31 | 12–37 | 13–43 | 14–49 | 15–55 | 16–61 | 17–67 | 18–73 |
| | 8–13 | 9–19 | 11–24 | 12–30 | 14–35 | 16–40 | 18–45 | 19–51 | 21–56 | 23–61 | 25–66 |
| 8 | 9–15 | 10–22 | 11–29 | 13–35 | 14–42 | 16–48 | 17–55 | 19–61 | 23–68 | 21–75 | 23–81 |
| | 9–15 | 11–21 | 13–27 | 15–33 | 17–39 | 19–45 | 21–51 | 23–57 | 25–63 | 27–69 | 30–74 |
| 9 | 10–17 | 12–24 | 13–32 | 15–39 | 17–46 | 19–53 | 21–60 | 22–68 | 24–75 | 26–82 | 27–90 |
| | 10–17 | 12–24 | 15–30 | 17–37 | 20–43 | 22–50 | 25–56 | 27–63 | 29–70 | 32–76 | 35–82 |
| 10 | 11–19 | 13–27 | 15–35 | 18–42 | 20–50 | 22–58 | 24–66 | 26–74 | 28–82 | 30–90 | 32–98 |
| | 11–19 | 14–26 | 17–33 | 20–40 | 22–48 | 25–55 | 28–62 | 31–69 | 34–76 | 37–83 | 39–91 |
| 11 | 12–21 | 15–29 | 17–38 | 20–46 | 22–55 | 25–63 | 27–72 | 30–80 | 32–89 | 34–98 | 37–106 |
| | 13–20 | 16–28 | 19–36 | 22–44 | 25–52 | 28–60 | 32–67 | 35–75 | 38–83 | 41–91 | 44–99 |
| 12 | 14–22 | 16–32 | 19–41 | 22–50 | 25–59 | 28–68 | 31–77 | 33–87 | 36–96 | 39–105 | 41–115 |
| | 14–22 | 17–31 | 21–39 | 24–48 | 28–56 | 31–65 | 35–73 | 39–81 | 42–90 | 46–98 | 49–107 |
| 13 | 15–24 | 18–34 | 21–44 | 24–54 | 28–63 | 31–73 | 34–83 | 37–93 | 40–103 | 43–113 | 46–123 |
| | 15–24 | 19–33 | 23–42 | 27–51 | 31–60 | 35–69 | 38–79 | 43–87 | 47–96 | 50–106 | 54–115 |
| 14 | 16–26 | 20–36 | 23–47 | 27–57 | 30–68 | 34–78 | 37–89 | 41–99 | 44–110 | 48–120 | 51–131 |
| | 17–25 | 21–35 | 25–45 | 29–55 | 33–65 | 38–74 | 42–84 | 46–94 | 51–103 | 55–123 | 59–123 |
| 15 | 18–27 | 21–39 | 25–50 | 29–61 | 33–72 | 37–83 | 41–94 | 44–106 | 48–117 | 52–128 | 56–139 |
| | 18–27 | 22–38 | 27–48 | 32–58 | 36–69 | 41–79 | 46–89 | 50–100 | 55–110 | 60–120 | 64–131 |
| 16 | 19–29 | 23–41 | 27–53 | 32–64 | 36–76 | 40–88 | 44–100 | 48–112 | 52–114 | 57–135 | 61–147 |
| | 19–29 | 24–40 | 29–51 | 34–62 | 39–73 | 44–84 | 49–95 | 54–106 | 59–117 | 64–128 | 69–139 |
| 17 | 20–31 | 24–44 | 29–56 | 34–68 | 38–81 | 43–93 | 48–105 | 52–118 | 57–130 | 62–142 | 66–155 |
| | 21–30 | 26–42 | 31–54 | 36–66 | 42–77 | 47–89 | 53–100 | 58–112 | 63–124 | 69–135 | 74–147 |
| 18 | 21–33 | 26–46 | 31–59 | 36–72 | 41–85 | 46–98 | 51–111 | 56–124 | 61–137 | 66–150 | 71–163 |
| | 22–32 | 27–45 | 33–57 | 39–69 | 45–81 | 50–94 | 56–106 | 62–118 | 68–130 | 73–143 | 79–155 |
| 19 | 23–34 | 28–48 | 33–62 | 39–75 | 44–89 | 49–103 | 55–116 | 60–130 | 65–144 | 71–157 | 76–171 |
| | 23–34 | 29–47 | 35–60 | 41–73 | 47–86 | 53–99 | 60–111 | 66–124 | 72–137 | 78–150 | 84–163 |
| 20 | 24–36 | 29–51 | 35–65 | 41–79 | 46–94 | 52–108 | 58–122 | 63–137 | 69–151 | 75–165 | 80–180 |
| | 24–36 | 31–49 | 37–63 | 43–77 | 50–90 | 57–103 | 63–117 | 70–130 | 76–144 | 82–158 | 89–171 |

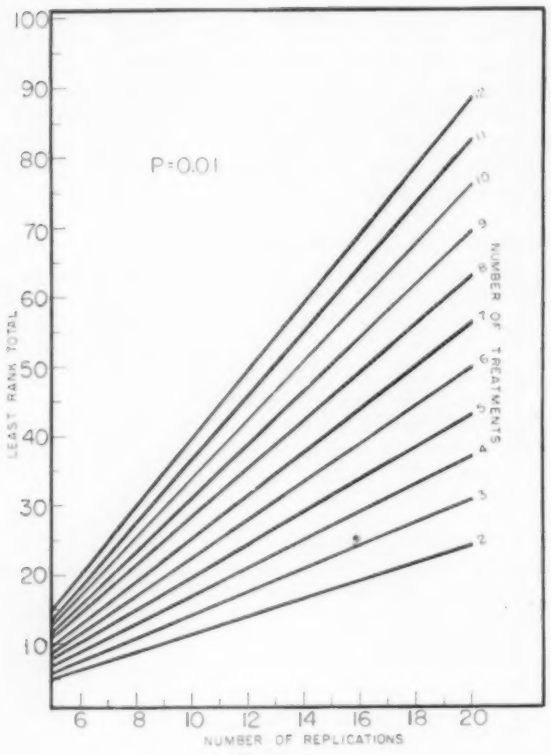


Figure 1.

of the number of replicates, or $t^r$, which in our example would be $5^8$, or 390,625. Of these 390,625 possibilities, a rank sum of 8 could occur once, and a rank sum of 40 could also occur once. The remaining possibilities would be distributed symmetrically among the other possible rank sums, reaching a peak at $\frac{1}{2}(40 + 8)$, or 24. The frequency for each rank sum is equivalent to the respective coefficient of the expanded multinomial, and can be obtained from a table of binomial coefficients, part of which is shown as Table 3.

To obtain a given probability we would multiply the total number of permutations $t^r$ by the probability level. Thus, for a probability of p = .05, for 5 treatments replicated 8 times, $(5^8)$ (.05) = 19,531. We now enter the table of binomial coefficients column *n/r*, and find the row containing the values equal or smaller than $(t^r)(P)$, and read in the N column the value which is equivalent to the largest rank sum which may occur at a probability of P or less. In our example, we enter the table of binomial coefficients in column n/8 and stop at 12,870, since the next value of 24,310 is larger than 19,531. Reading across, to the N column, we find the value of 16. We conclude that the accumulated probabilities of rank sums 8 to 16 will be no greater than P = .05. Thus, the entry for

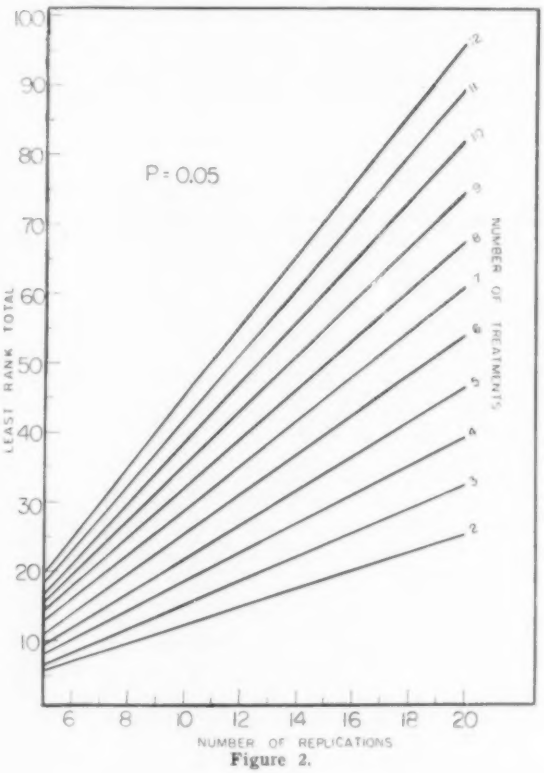


Figure 2.

**TABLE 3**
**Binomial coefficients**

| n | n/0 | n/1 | n/2 | n/3 | n/4 | n/5 | n/6 | n/7 | n/8 | n/9 | n/10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | | | | | | | | | | |
| 1 | 1 | 1 | | | | | | | | | |
| 2 | 1 | 2 | 1 | | | | | | | | |
| 3 | 1 | 3 | 3 | 1 | | | | | | | |
| 4 | 1 | 4 | 6 | 4 | 1 | | | | | | |
| 5 | 1 | 5 | 10 | 10 | 5 | 1 | | | | | |
| 6 | 1 | 6 | 15 | 20 | 15 | 6 | 1 | | | | |
| 7 | 1 | 7 | 21 | 35 | 35 | 21 | 7 | 1 | | | |
| 8 | 1 | 8 | 28 | 56 | 70 | 56 | 28 | 8 | 1 | | |
| 9 | 1 | 9 | 36 | 84 | 126 | 126 | 84 | 36 | 9 | 1 | |
| 10 | 1 | 10 | 45 | 120 | 210 | 252 | 210 | 120 | 45 | 10 | 1 |
| 11 | 1 | 11 | 55 | 165 | 330 | 462 | 462 | 330 | 165 | 55 | 11 |
| 12 | 1 | 12 | 66 | 220 | 495 | 792 | 924 | 792 | 495 | 220 | 66 |
| 13 | 1 | 13 | 78 | 286 | 715 | 1287 | 1716 | 1716 | 1287 | 715 | 286 |
| 14 | 1 | 14 | 91 | 364 | 1001 | 2002 | 3003 | 3432 | 3003 | 2002 | 1001 |
| 15 | 1 | 15 | 105 | 455 | 1365 | 3003 | 5005 | 6435 | 6435 | 5005 | 3003 |
| 16 | 1 | 16 | 120 | 560 | 1820 | 4368 | 8008 | 11440 | 12870 | 11440 | 8008 |
| 17 | 1 | 17 | 136 | 680 | 2380 | 6188 | 12376 | 19448 | 24310 | 24310 | 19448 |
| 18 | 1 | 18 | 153 | 816 | 3060 | 8568 | 18564 | 31824 | 43758 | 48620 | 43758 |
| 19 | 1 | 19 | 171 | 969 | 3876 | 11628 | 27132 | 50388 | 75582 | 92378 | 92378 |
| 20 | 1 | 20 | 190 | 1140 | 4845 | 15504 | 38760 | 77520 | 125970 | 167960 | 184756 |

the smaller value of the lower entries for t = 5, r = 8 in Table 1 is 1 + 16, or 17.

Since the multinomial distribution is symmetrical, we obtain the larger value in the lower pair by subtracting the difference between 8 and 17 from the largest possible rank sum, which in our example would be 40–9, or 31, and we state that any rank sum greater than 31 may appear at a probability of .05 or less.

If we are not prepared to specify a particular treatment in advance, then clearly the probability of any treatment rank sum is not $(t^r)(P)$, but $(t^r)(Pt)$. Thus to reduce the probability for *any* treatment comparison to the same level as when specifying one treatment in advance, we must divide by t, or $(t^r)(P/t)$; which in our example would be $(5^8)(.05/5) = 3{,}906$. Entering the table of binomial coefficients at n/8, we find 3003 which indicates N = 14. Thus, the smaller value for the upper pair is entered in Table 1 as 15, and since 15 − 8 = 7, the larger value for the upper pair is 40 − 7, or 33.

Tables similar to Table 1 may be constructed for any given probability. Thus, if a 1% (P = .01) significance table is desired, the entries could be determined by $(t^r)(.01)$ for the lower pairs, and $(t^r)(.01/t)$ for the pair of upper entries.

It may be of interest to point out that the table of binomial coefficients may be expanded conveniently since any value *Nij* may be obtained by the addition of Ni − 1, j − 1 + Ni, j − 1. Also, as shown in Figure 1 (P = 0.01) and Figure 2 (P = 0.05) the significant rank sums have a linear relation to number of replications, and the treatments are evenly spaced so that such tables could be expanded substantially by graphic interpolation with little loss in precision.

LITERATURE CITED

1. Box, G. E. P. Evolutionary operation: A method for increasing industrial productivity. *Proc. Second Stevens Symposium on Statistical Methods in the Chemical Industry.* pp. 29–49. Hoboken, N. J. 1958.
2. Bradley, R. A., and Kramer, A. Addenda to a quick, rank test for significance of differences in multiple comparisons. *Food Technol.*, 11, 412 (1957).
3. Kramer, A. A quick rank test for significance of difference in multiple comparisons. *Food Technol.*, 10, 391 (1956).
4. Snedecor, G. W. *Statistical Methods.* pp. 251–253. 5th ed. 1956. The Iowa State College Press, Ames, Iowa.

# Variations and Their Causes in the Measurements of Beef Tenderness by the Electric Meat Grinder Method[a]

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(Manuscript received May 18, 1960)

The best known mechanical methods of measuring meat tenderness are those associated with the Warner-Bratzler Shear,[b] Penetrometer, Christel Texturemeter, the orifice, and the electric meat grinder. This study was conducted to investigate the causes of variations in the meat grinder method.

The measure of the resistance to grinding of meat as an indication of its tenderness was described in detail by Mayida and Tappel *(2)*. By using a homogeneous substance (wax), they obtained a coefficient of variation of 2% for both the Christel Texturemeter and the food grinder. This compared to a coefficient of variation of 4.7% to 9% for the Warner-Bratzler Shear.

Bockian, Anglemier, and Sather *(1)* reported on a comparison of an objective and subjective measurement of beef tenderness, using the meat grinder for the objective measurements and the scores of a trained panel of judges for the subjective. They obtained correlation coefficients of .59 and .60 between objective and subjective measurements. Duplicate samples of beef indicated a variation of 10%. Bockian *et al (1)* recommended further improvements on the electric grinder method by using a recording ammeter (in

[a] Presented at the Twentieth Annual Meeting of the Institute of Food Technologists, May 18, 1960, San Francisco, California.

[b] Among these, the Warner-Bratzler is reported used most exclusively in the United States *(1)*.

lieu of a conventional ammeter), and a mechanical cuber.

## TEST PROCEDURE

**Test product, handling and sampling procedure.** Ten-pound, top rounds of beef (choice grade), roasted at 300° F in a conventional oven to an internal low point temperature of 150° F, were used as the test product. The meat was cooled to room temperature (68–72° F) before sampling. Sample cores were randomly cut from the test product by using a No 15 cork borer (approximately ¾ in dia). Cores were sliced into slugs ½ in long. Fifty-gram samples (11–13 slugs) were randomly selected from each round for power determinations.

**Apparatus.** A Hobart model N-50 mixer (1/6 HP, 115 v, 2.85 amp, 60 cycle, AC) with grinder attachment was used as the test instrument. A Duncan Portable Watt-Hour Test Meter, Model M-1, was used in place of an ammeter to measure the power consumption.[c] The accuracy of this instrument is 0.3%. The line voltage was maintained by a Superior Electric Co. Powerstat Autotransformer, Type S 1028, rated 115 v, 2.4 KVA. An Esterline Angus Graphic Voltmeter, Model AW, 115 v, was used to record the load voltage. Time was recorded by a Labline Inc. electric timer, recording to .01 sec. Figure 1 is a schematic diagram of the electrical circuit.

**Preliminary tests.** Preliminary test runs were made to determine refinements in the testing procedure necessary to insure reproducible measurements of tenderness. A thorough study revealed that variations were principally caused by changes of motor resistance, fluctuations of line voltage, and changes in friction of rotating grinder elements.

1. *Variations due to changes of motor resistance*

The first step was to establish a uniform warm-up period for the grinder. The temperature rise of a motor will affect the resistance of its coils, resulting in a significant variation in power consumption. To determine the time necessary to stabilize the motor temperature, the motor was operated at no-load, starting from a cold position, and power consumption per minute was recorded at 5-min intervals, until uniform power consumption was attained.

2. *Line voltage fluctuations*

A great source of error was traced to small variations of line voltage. A study was made on the magnitude of this effect on the power reading. The motor was stabilized at no-load and the power consumption was recorded at two volt intervals from 112 to 120 v. The consumption in watt-hours was plotted against line voltage to graphically indicate the effect of line voltage.

3. *Variation in load caused by friction of movable grinder elements*

It was noted that there was a variation in the no-load power when the grinder head was reassembled and replaced after washing and drying. A slight difference in hand pressure, when tightening the plate retaining ring of the grinder head, caused a variation in the friction between the rotating feed screw and knife with the perforated plate and bearings. To correct this, a hole was drilled through the retaining ring and through the grinder head, into which a removable pin was inserted. The ring was now located in a fixed position with reference to the grinder head body.

**Operating procedure.** The meat grinder was switched on for a warm-up period of 80 min. The line voltage was regulated and maintained constant by means of the Powerstat Autotransformer. No-load power was recorded for runs of 60-sec duration until 5 consecutive runs were obtained with practically nonvarying power consumption (± .013 whr). The power consumption of the last run was taken as the no-load power. On the sixth run, a 50 g sample was gravity fed into the grinder at the uniform rate of one slug every .05 sec. At the end of 60 sec, the power was switched off and the power consumed, as indicated by the whr meter, recorded. The power required to grind the 50 g sample was the grinder power consumption under load minus the no-load power.

The grinding head, consisting of the feed screw, rotating knife, perforated plate, plate retaining ring, and the housing, was washed, dried, and replaced with the locating pin in place. The above procedure was repeated for the duplicate sample. The difference between the values of the two determinations was used as a measure of the variability (reproducibility) of this method of measuring tenderness.

## FINDINGS

1. In recording the no-load power consumption at 5-min intervals, beginning with a cold start, it was found that a constant value was not attained before an elapsed time of approximately 80 min. A characteristic curve of power consumption vs. time is plotted in Figure 2.

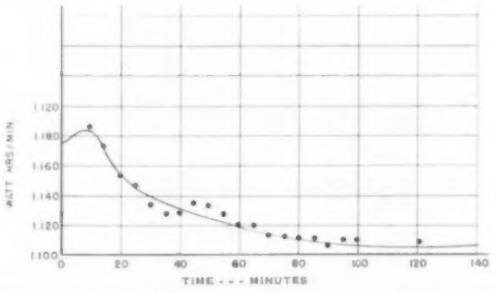



**Figure 2. No-load power consumption per minute vs. time, for Hobart mixer model N 50.**

2. The effect of changes in line voltage upon the no-load power consumption is plotted in Figure 3. It was found that a change of one volt (or less than 1% of line voltage) caused a change of .025 whr or approximately $\frac{.025}{.200} = 12.5\%$ in the power consumption of an average load of .200 whr. By means of adjusting the Powerstat, it was possible to maintain an exact line voltage (Figure 4). The no-load readings were now reproducible within .00667 whr, or $\frac{.0066}{.180} = .379\%$, using the average value of the no-load power as .180 whr.

3. The retaining ring of the grinder was returned to the same fixed position on the grinder housing by means of the locating pin. As a result, the friction of the moving parts remained constant. It was found that the no-load runs, with line voltage maintained constant, were now reproducible within .00667 whr.

All the apparatus used for the meat grinder operational tests are illustrated in Figure 5.

[c] The 10-amp range was used in lieu of the 5 amp range in order to prevent possible injury to the meter due to the starting current surge of an induction motor.

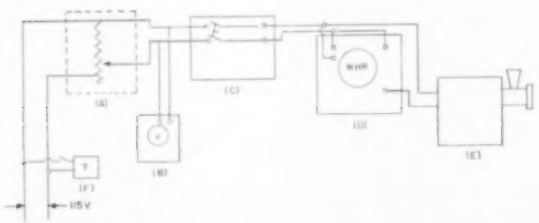



**Figure 1. Schematic diagram of instrumentation for meat grinder power measurements. (A) Powerstat for controlling line voltage. (B) Recording meter for line voltage. (C) Switch box. (D) Duncan portable test meter. (E) Hobart meat grinder. (F) Timer.**

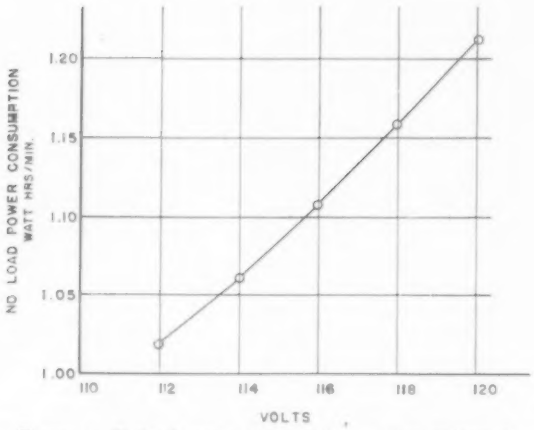



**Figure 3. No-load power consumption vs. line voltage of a Hobart model N 50 meat grinder.**

## DISCUSSION

**Stabilizing of motor.** The findings indicate the necessity of a warm-up period before stable values may be attained. The power consumption of a motor is maximum at the start and decreases with time, until a condition of stabilization is reached. This is due to a rise in resistance value of the copper field coils with increase of temperature. The actual change in resistance may be computed from the formula

$$R_{t2} = R_{t1} [1 + a_1 (t_2 - t_1)]$$

$R_{t2}$ = final resistance of wire in ohms
$R_{t1}$ = initial resistance of wire in ohms
$t_2$ = final temperature of wire in degrees centigrade
$t_1$ = initial temperature of wire in degrees centigrade
$a_1$ = temperature coefficient of copper wire

In the operating range of this study, the change in resistance may be considered proportional to the change in temperature. It is therefore evident that the temperature of the motor must reach a constant value before it will operate at a non-variable rate of power consumption.

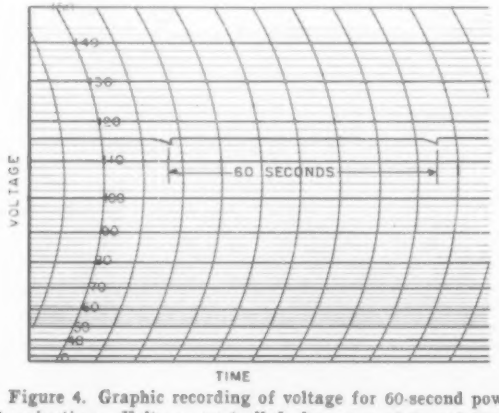



**Figure 4. Graphic recording of voltage for 60-second power determination. Voltage controlled by powerstat autotransformer.**

The graph in Figure 3 indicates the relatively great influence a small fluctuation in line voltage has on the power input. From the relationship

$$P = \frac{E_2}{R}$$

it is seen that the power is proportional to the square of the voltage. As the load power is small, the effect of a small change in voltage becomes an important factor.

The accurate determinations of power was made possible by the use of a Powerstat Autotransformer and a recording voltmeter to maintain a constant voltage to $\pm$ .1 v. A line fluctuation could easily be corrected before an error would become significant. The steady state condition of line voltage attainable by this method is illustrated by the graphic recording, Figure 4. The same degree of accuracy obtainable in an automatic voltage regulator would require a rather costly precision instrument. (The commercial grade of regulators operating at a regulation of approximately $\pm$ 1% would be inadequate.)

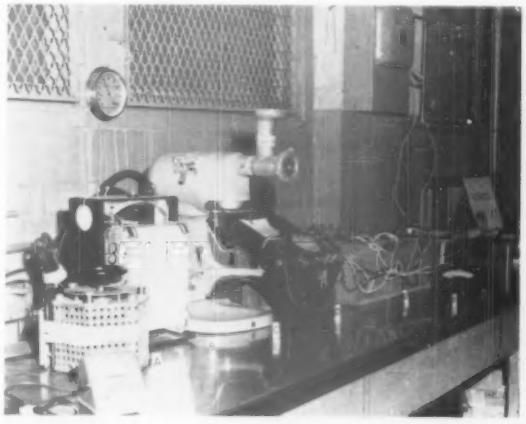


**Figure 5. Electrical instruments and apparatus used in meat grinder determinations.**

The current variation due to a 50 g load of a Hobart model N-50 is imperceptible for practical purposes, due to the relative large idling current of the motor. The Duncan Portable Watt-Hour Meter is adequately sensitive to minute changes of power, and it eliminates the possible human error of recording at 5-sec intervals as done by Miyada and Tappel *(2)*. The uses of a power meter results in a greater accuracy than attainable by an ammeter alone as the power factor at various loads would be inherently corrected.

The readings of the Duncan meter are readily converted to Joules to permit comparison with the work of others. One revolution of the meter registers $\frac{2}{3}$ whr. As the dial is divided into 100 subdivisions, each subdivision therefore becomes

$$\frac{.667}{100} = .00667 \text{ whr or}$$

$$.00667 \times 3600 = 24 \text{ Joules}$$

An average sample of 50 g of beef registers 33.5 subdivisions. On this basis, the average Joules/g will be

$$\frac{33.5}{50\,g} \times 24 \text{ Joules} = 16.1$$

This compares with a range of 10.4 to 16.2 Joules per g as determined by Bockian *et al* (1), based on 10 samples.

The direction of the grain in the beef has little or no effect on the grinder tenderness determinations, but it is of major significance in the other two methods. In many samples, the true grain pattern was difficult to discern.

In order to further reduce some variations in tenderness measurements that are still present in the grinder method, it is recommended that an automatic timer be used in the power circuit. The timer should shut off the grinder motor at the end of the test run. Investigations indicated that there was an error introduced by operating the switch manually.

The meat grinder chosen for a tenderness measurement should not be larger than the size of the average kitchen type, for the reason indicated by the following relationship:

$$\text{total power} = \text{no load power} + \text{load power}$$

It is evident from the above that the recorded total power will be in a greater proportion to the load power if the no-load power is kept to a minimum. This will result in a more sensitive recording of the measurement of tenderness.

To compare the variation of tenderness measurements of the meat grinder with other methods, tests were conducted simultaneously using the Warner-Bratzler Shear and the Orifice methods. Samples for the three methods were taken from the same section of beef. The resulting coefficients of variation are listed in Table 1. On the basis of 33 tests, the coefficient of variation for the meat grinder was 5.5% against 15% for the Orifice method, and 19.4% for the Warner-Bratzler Shear method.

**TABLE 1**

**A comparison of the coefficient of variation for three methods of measuring meat tenderness based on 33 tests**

| Method | Average mean | Average standard of deviation* | Average coefficient of variation** |
|---|---|---|---|
| Warner-Bratzler Shear | 15.2 lb* | 2.97* | 19.4% |
| Orifice | 551.4 lb/sq in* | 82.8* | 15% |
| Meat Grinder | .227 whr | .0193 | 5.57% |

* Schoman, Jr., C. M., "The Effect of Oven Air Temperature, Circulation and Pressure on the Roasting of Top Rounds of Beef and on Factors Determining its Acceptability." Rutgers, The State University, New Brunswick, New Jersey, April 1960.

Each test consisted of 10 Warner-Bratzler Shear or Orifice determinations, 5 determinations were made on one meat plug parallel to the grain and 5 determinations were made on another meat plug perpendicular to the grain. Both plugs were taken from approximately the same part of the meat (top round). These were added and averaged. The 33 individual tests were added and averaged in order to obtain the Average Mean. The standard deviation was determined by first checking for homogeneity of variances between samples parallel and perpendicular to grain; this was done by using the "F" test. There was no reason to believe that the variances were different at a .05 level of significance; therefore, the variances were combined and the average standard deviation determined from the 33 tests. The meat plugs obtained from the Warner-Bratzler Shear determinations were used in the meat grinder determinations. Each meat grinder determination consisted of grinding 11–13 plugs of meat, 5–6 of which were obtained from the Warner-Bratzler Shear determinations.

** The coefficient of variation was determined by the standard of deviation (s) and the mean (x) in the following relationship:

C of $V = \frac{s}{x}$ where the standard of deviation is the average range (R) divided by 1.128 when the sample size is 2 or 2.326 when the sample size is 5.

The variable friction of the rotating grinder elements was overcome by inserting a removable locating pin through the retaining ring and into the grinder head housing. This served to prevent excessive tightening of the ring which caused a variable friction between rotating parts.

The incorporation of the above refinements has resulted in a high degree of reproducibility in the measurements of tenderness of duplicate samples of beef. The average coefficient of variation obtained by this method was 5.57% compared with 15% in the Orifice Method and 19.4% in the Warner-Bratzler Shear Method.

## SUMMARY

Preliminary tests were conducted to determine the causes of variation in the measurement of meat tenderness using the meat grinder method. The principal causes were found to be due to changes in the motor temperature, fluctuations of line voltage, and the variable friction of the rotating grinder elements.

The variations of the motor temperature caused a change in the power consumption of the motor. It was found that a warm-up period of 80 minutes was adequate to establish a constant temperature and, therefore, a uniform rate of power consumption.

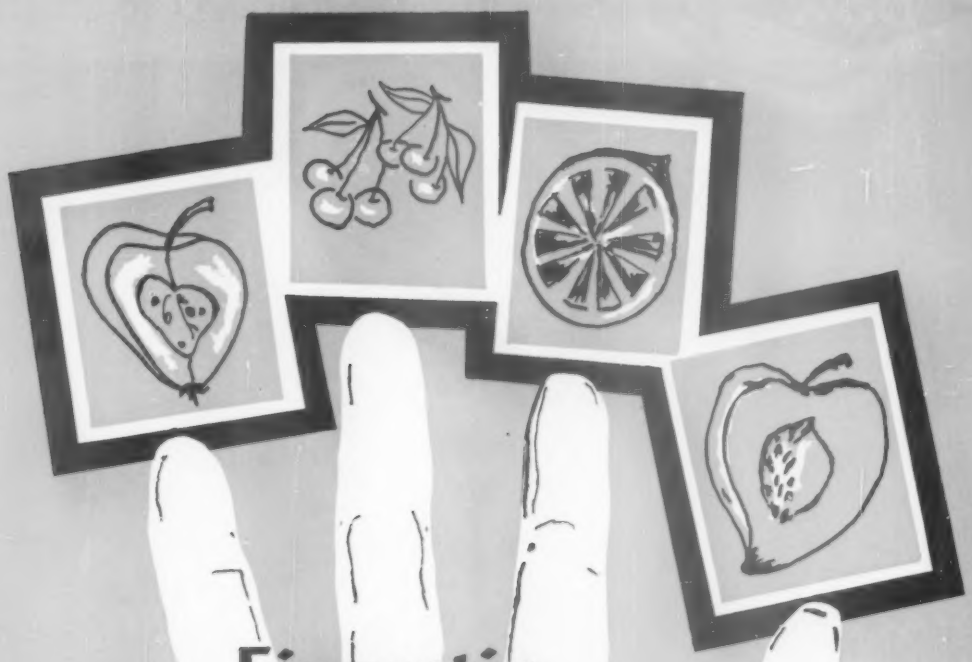
The line voltage fluctuations were effectively controlled by incorporating a Powerstat Autotransformer in the power circuit. Manual adjustment of the Powerstat resulted in a constant voltage.

## RECOMMENDATION

A further improvement in the measurement of tenderness by the Meat Grinder Method can be achieved by incorporating an automatic timer in the power circuit. The timer would shut off the meat grinder at the end of a pre-set run. This would prevent a significant error introduced by operating the switch manually. Tests indicated that small kitchen mixers should give the best results.

## LITERATURE CITED

1. Bockian, A. H., Anglemier, A. F., and Sather, L. A. A comparison of an objective and subjective measurement of beef tenderness. *Food Technol.*, 12, 483 (1958).
2. Miyada, D. S., and Tappel, A. L. Meat tenderization. I. Two mechanical devices for measuring tenderness. *Food Technol.*, 10, 142–145 (1956).



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# In Vitro Effects of Chlortetracycline on Bacteria Indigenous to Gulf Shrimp and Oysters*

**Arthur F. Novak, Ernest A. Fieger and Keith A. Stolzle**

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(Manuscript received May 16, 1960)

SPOILAGE OF SHELLFISH has been attributed to enzymatic degradation caused by contaminating microorganisms. Several publications by Tarr *(12)*, Gillespie *(9)* and Farber *(15)* have reported antibiotics to be beneficial in retarding bacterial spoilage of seafood products.

Use of chlortetracycline (CTC) in shellfish preservation has been studied by Abbey *(1)*, Bailey *(2)*, Boyd *(3)*, Camber *(4)*, Farber *(6)*, Fieger *(7, 8)*, Higman *(10)*, Novak *(11)* and Vance *(12)*. Inclusion of CTC in dips and washes for shrimp and oysters prior to packing has resulted in an extension of their ice storage life. Experimental evidence suggests this prolonged quality retention is the result of maintaining reduced bacterial counts in CTC treated samples.

This experiment was designed to determine and compare the degree of inhibition of bacteria indigenous to Gulf shrimp and oysters in solutions containing 5 and 20 ppm CTC. Microorganisms commonly found on these shellfish in their environment have been isolated, identified according to genus, and tested for their ability to survive and reproduce in media containing these concentrations of CTC.

Although numerous species of bacteria, yeasts and molds have been isolated from Gulf shrimp and oysters, only a relatively small number have been isolated repeatedly.

## EXPERIMENTAL

**Materials.** *Oysters:* Commercially shucked select oysters *(Ostrea virginica)* purchased in New Orleans, were packed unwashed in gallon cans, placed in ice in Arctic hampers, and transported to the laboratory in Baton Rouge, where they were used within 3 hr. All oysters were from Louisiana beds.

*Shrimp:* All of the shrimp *(Penaeus setiferus)* were collected by trawling for 30 min in Barataria Bay, Louisiana; or in the Gulf adjacent to the Bay. After landing the catch on deck, trash fish were separated, the shrimp were headed and washed with sea water. Shrimp were brought to the Louisiana Fish and Wildlife laboratory at Grand Terre and used within 2 hr after landing.

Both air and sea water temperatures on the fishing grounds ranged from 15° C to 35° C during collection of the oysters and shrimp.

**Preparation of samples.** *Oysters:* Approximately 100 g of drained oysters were homogenized with an equal amount of sterile distilled water in a Waring blender for 3 min, and then serial dilutions were prepared from the homogenate.

*Shrimp:* Approximately 25 g of drained, headed shrimp were homogenized with sufficient sterile distilled water to make a 1 to 10 dilution. After mixing in a Waring blender for 3 min, serial dilutions were prepared from the homogenate.

**Isolation and identification of microorganisms.** *Oyster media:* Nutrient agar and broth containing 0.5% sodium chloride and 2% oyster fluid were prepared.

*Shrimp media:* Nutrient agar and broth containing 0.5% sodium chloride and 2% homogenized shrimp (1 part shrimp, 2 parts water) were prepared.

All media were adjusted to pH 7.0, and autoclaved at 121° C for 15 min.

Aliquots of the serial dilutions of oysters and shrimp were plated on the appropriate agar for total counts and isolation of the organisms. All plates were incubated for 72 hr at 28° C. Selected isolates were transferred to and maintained on slants or stabs of the same agar for the purpose of identification.

Organisms were identified by morphological and cultural characteristics according to procedures listed in the *Manual of Methods for Pure Culture Study of Bacteria*, and other sources where necessary. Allocation into a genus was made from *Bergey's Manual of Determinative Bacteriology*. Since several species exhibiting distinct biochemical differences were unclassified in the manual, and since in most instances these different species of the same genus reacted uniformly to the antibiotic, definite classification was not considered necessary.

**Method for inhibition tests.** Solutions of CTC were made with sterile distilled water and added to the broths described previously so that the final concentrations of CTC were 5 and 20 ppm. Inoculations were then made with one drop of 18 hr cultures grown in the appropriate broth. All tubes were incubated at 28° C, and the degree of inhibition was recorded after 1, 3, 7 and 14 days. Tests were repeated during the year from new isolations of the organisms made during each season to determine whether or not the same organisms are predominant, and to ascertain if any seasonal changes would affect their reaction to CTC.

Organisms isolated from Gulf oysters and shrimp and their sensitivity to chlortetracycline are shown in Tables 1 and 2.

## RESULTS AND DISCUSSION

A majority of the predominant and often recurring bacteria in oysters and shrimp were inhibited for 3 days in 5 ppm CTC, but all of these organisms were inhibited for 3 days by 20 ppm CTC.

None of the organisms tested were inhibited completely for 7 days in 5 ppm CTC, although the turbidity in most tubes was less than in the controls. However, most of the cultures were inhibited completely for 7 days by 20 ppm CTC.

All organisms tested showed some degree of growth in all concentrations of CTC after 2 and 3 weeks.

Organisms considered to be an index of pollution were found on some oysters which were cultivated in inland areas where such contaminants sometime occur.

Very few coliform organisms were isolated from shrimp immediately after catching, and could not be listed in the often recurring category. Most contaminants were bacteria usually found in salt water.

Concentration of 10 ppm CTC was also evaluated, and its effectiveness in inhibiting the isolates from both shellfish was almost identical with results obtained in 5 ppm CTC.

* Presented at the Twentieth Annual Meeting of the Institute of Food Technologists, May 18, 1960, San Francisco, California.

**TABLE 1**

**Inhibition of bacteria in oysters by chlortetracyline**

| Organism | No of species | 5 ppm CTC | | | 20 ppm CTC | | |
|---|---|---|---|---|---|---|---|
| | | Days | | | Days | | |
| | | 1 | 3 | 7 | 1 | 3 | 7 |
| Predominant | | | | | | | |
| Achromobacter | 3 | + | + | − | + | + | +(2) − (1) |
| Pseudomonas | 2 | + | +(1) − (1) | − | + | + | +(1) − (1) |
| Alkaligenes | 2 | + | + | − | + | + | + |
| Often recurring | | | | | | | |
| Aeromonas | 2 | + | + | − | + | + | + |
| Aerobacter | 1 | + | − | − | + | + | + |
| Escherichia | 1 | + | + | − | + | + | + |
| Flavobacterium | 3 | + | + | − | + | + | +(2) − (1) |

Numbers in parentheses refer to no of species inhibited or not inhibited. + Inhibition. − No inhibition.

**TABLE 2**

**Inhibition of bacteria in shrimp by chlortetracycline**

| Organism | No of species | 5 ppm CTC | | | 20 ppm CTC | | |
|---|---|---|---|---|---|---|---|
| | | Days | | | Days | | |
| | | 1 | 3 | 7 | 1 | 3 | 7 |
| Predominant | | | | | | | |
| Achromobacter | 4 | + | + | − | + | + | +(3) − (1) |
| Flavobacterium | 4 | + | +(3) − (1) | − | + | + | + |
| Agarbacterium | 3 | + | +(2) − (1) | − | + | + | + |
| Often recurring | | | | | | | |
| Aeromonas | 2 | + | + | − | + | + | + |
| Pseudomonas | 2 | + | +(1) − (1) | − | + | + | +(1) − (1) |
| Chromobacterium | 1 | + | + | − | + | + | + |

Numbers in parentheses refer to no of species inhibited or not inhibited. + Inhibition. − No inhibition.

Yeasts isolated from shellfish included *Saccharomyces, Candida, Rhodotorula, Torulopsis, Hansenula, Cryptococcus* and "black yeasts." None of these were inhibited by CTC in the concentrations studied.

## SUMMARY

Most bacteria found on Gulf oysters belong to the genera *Achromobacter, Pseudomonas, Alkaligenes, Aeromonas, Aerobacter, Escherichia,* and *Flavobacterium.*

Most bacteria found on Gulf shrimp belong to the genera *Achromobacter, Flavobacterium, Agarbacterium, Aeromonas, Pseudomonas,* and *Chromobacterium.*

Concentrations of 5 to 20 ppm CTC inhibit growth of these organisms for periods of three to seven days when tested in vitro.

Predominant and often recurring organisms found on Gulf shrimp and oysters are present during all seasons of the year, and new isolations of these organisms made during different weather periods were not affected in their reaction to CTC.

## CONCLUSIONS

Employment of washes and dips of 5 to 20 ppm CTC have been reported to extend the ice storage life of Gulf oysters and shrimp for a period of 3 to 5 days. Results reported here show that these concentrations of CTC inhibit growth of most bacteria indigenous to these shellfish for a similar period of time when tested in vitro.

## LITERATURE CITED

1. Abbey, A., Kohler, A. R., and Upham, S. D. Effect of aureomycin chlortetracycline in the processing and storage of freshly shucked oysters. *Food Technol.*, **11**, 265 (1957).
2. Bailey, M. E., Fieger, E. A., and Novak, A. F. Objective tests applicable to quality studies of ice stored shrimp. *Food Research*, **21**, 611 (1956).
3. Boyd, J., and Tarr, H. L. A. Effect of chlortetracycline and storage temperatures on the quality of shucked oysters. *Progress Repts., Pacific Coast Stations*, **105**, 12 (1956).
4. Camber, C. Issac. Aureomycin dips and ices for the preservation of shrimp. *Spec. Rept. No. 55-7*, The Marine Laboratory, Univ. of Miami (1955).
5. Farber, L. Antibiotics as aids in fish preservation. I. Studies on fish fillets and shrimp. *Food Technol.*, **8**, 503 (1954).
6. Farber, L., and Lerke, P. A. The effect of chlortetracycline on shrimp spoilage at various temperatures. *Proc., Gulf and Caribbean Fish Inst., 9th session.* pp. 26–31. The Marine Laboratory, Univ. of Miami (1956).
7. Fieger, E. A., Bailey, M. E., and Novak, A. F. Chemical ices for shrimp preservation. *Food Technol.*, **10**, 578 (1956).
8. Fieger, E. A., Bailey, M. E., and Novak, A. F. Effect of delayed handling upon shrimp quality during subsequent refrigerated storage. *Food Technol.*, **12**, 297 (1958).
9. Gillespie, D. C., Boyd, J. W., Bissett, H. M., and Tarr, H. L. A. Ices containing chlortetracycline in experimental fish preservation. *Food Technol.*, **9**, 296 (1956).
10. Higman, J. B., Idyll, C. P., and Thompson, J. Further experiments in holding fresh shrimp in refrigerated sea water and ice. *Proc., Gulf and Caribbean Fish Inst., 6th annual session.* pp. 114–121. The Marine Laboratory, Univ. of Miami (1953).
11. Novak, A. F., Fieger, E. A., and Bailey, M. E. Chlortetracycline for preserving Gulf oysters. *Food Technol.*, **12**, 237 (1958).
12. Tarr, H. L. A., Southcott, B. A., and Bissett, H. M. Effect of several antibiotics and food preservatives in retarding bacterial spoilage of fish. *Fisheries Research Board of Canada, Pacific Progress Rpts.*, **83**, 35–38 (1950).
13. Vance, M. H., Saenz, W., and Dubrow, D. L. The use of chlortetracycline in the control of spoilage in ice-stored shrimp. *Technical Series No. 28*, The Marine Laboratory, Univ. of Miami (1959).

# Volatiles Contributing to the Flavor of Bartlett Pears[a, b]

(Manuscript received May 31, 1960)

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A CONSIDERABLE AMOUNT of attention has been directed to the gross composition of pear fruits *(4, 15, 20)* and various workers have studied the specific groups of compounds that are present. Ash and Reynolds *(3)*, Phillips, Pollard and Whiting *(11)*, Tanner and Rentschler *(17)*, Ulrich and Thaler *(18)*, and Winkler *(21)* are among those giving particular attention to the organic acids. Strain *(16)*, Kidd *et al (7)*, and Martin *(8)* are among those who studied the various sugars and polyols of pears. An excellent literature review accompanies Hulme's *(6)* contribution. Antoniani, Federico, and Serini *(1)*, Antoniana and Serini *(2)*, and Serini *(13)* have attempted to correlate the degree of maturity with the content of biacetyl and acetoin. Pangborn and Leonard *(10)*, Simone *et al (14)* and Valdes, Simone and Hinreiner *(19)* have studied the effects and interrelationship of organic acids and added sugar to consumer acceptance. Claypool *et al (5)*, reporting on the influence of ripening temperature, maturity, and growing area on pear quality obtained a correlation between volatile reducing substances and decrease of pressure within the ripening fruit.

Little attention has been given the volatiles, which are ultimately responsible for the characteristic pear aroma. Although few fruits possess as tantalizing an aroma as fresh, well-ripened Bartlett pears, pear purees produced by conventional processes from this same fruit are notably flavorless and often insipid. In the conventional canning process, volatiles, including many that contribute to flavor, are driven off to the atmosphere with the result that the cannery is blanketed in a rich, desirable aroma, but the puree produced is almost totally lacking in flavor.

The design of an entirely closed processing system poses many problems, and reincorporation of volatiles expelled by the required heat would be difficult to control. This work was directed toward isolating these volatiles, and studying the influence of the intact mixture and its components on the flavor of Bartlett pears.

## EXPERIMENTAL

**Preparation of essence.** Fresh, ripe Bartlett pears, were processed in an enclosed system (Figures 1–3), ported at the end of the inclined thermal screw and at the disintegrator.[c] The volatiles expelled through these ports were conducted to two condensers in series, and trapped as aqueous essences. As indicated in Table 1, considerable variation was experienced in the volumes of essence recovered in different runs. Whether this variation was only in the quantity of aqueous carrier, or also influenced the amount of volatiles in the essences is not known at this time. Essences used in these studies were recovered from condenser No 2, and were much richer in aroma

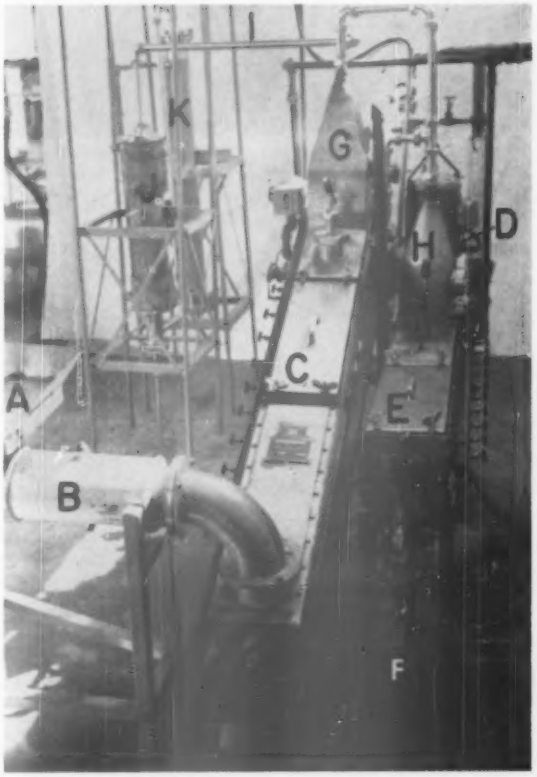


**Figure 1. Essence recovery unit. A, infeed hopper. B, infeed screw, sealed and enclosed. C, inclined thermal screw with neoprene-gasketed cover. D, disintegrator. E, thermal holding screw with neoprene gasketed cover. F, product discharge. G, vapor take-off No. 1. H, vapor take-off No. 2, I, vapor take-off line, connected to both vapor take-off No. 1 and No. 2. J, condenser No. 1. K, condenser No. 2.**

TABLE 1

Operating conditions and recoveries, essence recovery unit

| Pounds of pears | Temperatures, °C | | | Essence recovered | |
|---|---|---|---|---|---|
| | Inclined thermal screw | Holding screw | Discharge | Condenser 1 | Condenser 2 |
| 4207 | 215 | 210 | 192 | 164 lb | 2910 cc |
| 1078 | 210 | 200 | 180 | 22 lb | 435 cc |
| 780 | 210 | 180 | 178 | 63 lb | 600 cc |
| 1567 | 215 | 210 | 190 | 135.5 lb | 3270 cc |

[a] This project was supported in part by funds from Pear Zone No 1.

[b] Presented at the Twentieth Annual Meeting of the Institute of Food Technologists, San Francisco, May 18, 1660.

[c] Among those contributing to the design of this equipment were Professors G. L. Marsh and J. C. Harper, and S. Leonard.

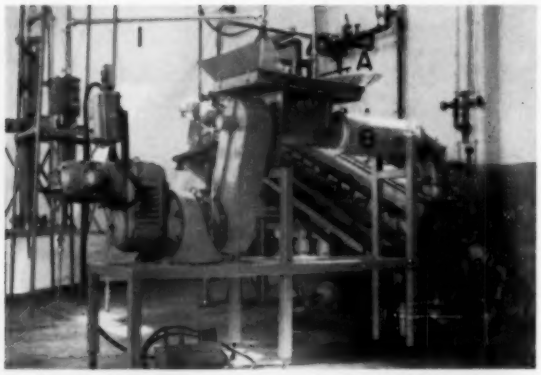


**Figure 2. Essence recovery unit. A, infeed hopper. B, infeed screw. C, inclined thermal screw. I, vapor take-off line. J, condenser No. 1. K, condenser No. 2.**

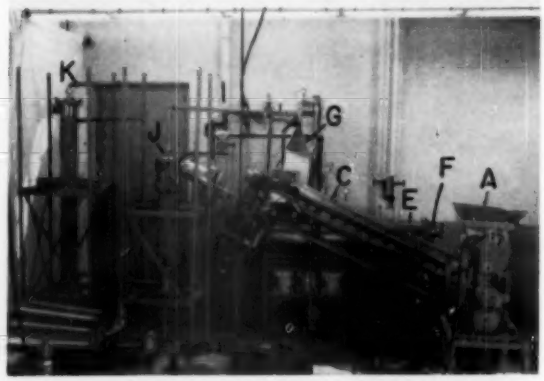


**Figure 3. Essence recovery unit. A, infeed hopper. C, inclined thermal screw. E, thermal holding screw. F, product discharge. G, vapor take-off No. 1. I, vapor take-off line. J, condenser No. 1. K, condenser No. 2.**

than the bulk essence recovered at condenser No 1. These essences possessed the typical desirable aroma of fresh Bartlett pears, and the addition of essence to pear purees resulted in striking flavor improvement. Essences were placed in polyethylene plastic bags, frozen and stored at 0° F.

**Preparation of extracts.** As needed, batches of essence were thawed, saturated with C.P. sodium chloride, and extracted with an organic solvent. Ethyl ether, pentane, isopentane, and ethyl chloride were tried. The latter was selected because it gave good extractions, and its lower boiling point permitted excess solvent to be removed more easily.

Extraction of 3 liters of aqueous essence was accomplished with 4 extractions, each using ca 300 cc ethyl chloride. The major portion of the extracting solvent was removed in a rotary flash evaporator, leaving perhaps 15 cc of material with a strong aroma of fresh pears. The actual concentration of residual ethyl chloride was not determined.

**Gas chromatography.** The concentrates were examined by gas chromatography on several types of columns, and the best results, in terms of maximum number of fractions and the degree of their separation, was achieved with diethyleneglycolsuccinate (DEGS) on Chromosorb. Figure 4 illustrates a typical curve at 175° C. Separations for aroma analyses were achieved on a commercial gas chromatograph, using a four-filament thermal conductivity cell, with separately heated injector and collector. The column was ¼ in x 10 ft, stainless steel, DEGS on Chromosorb at 175° C. The injector was maintained at 250° C and the collector at 275° C. The flow rate was 50 cc helium/minute. Fifty µl injections were made, and

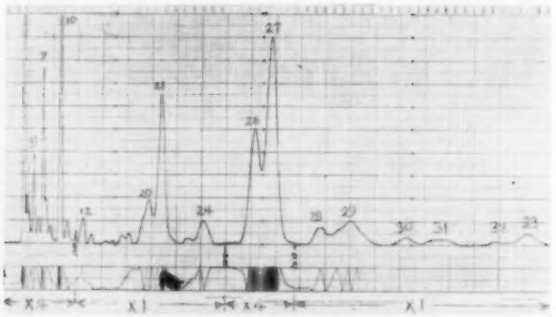


**Figure 4. Chromatogram of 1.5 µl of pear essence extract. ¼-in x 10-ft stainless steel column, 20% DEGS on Chromsorb at 175° C. Flow rate, 50 cc $He_2$/minute.**

separate glass collector tubes were inserted with each trap to avoid the danger of contamination of subsequent fractions by condensation within the lead out tube. Monel connector tubes were used with a ½ in x 5 ft preparatory column and 200 µl aliquots injected, in collecting samples for the taste analysis.

**Aroma evaluation.** Individual fractions and combinations thereof were collected for flavor analysis by bubbling the effluent from a gas chromatograph (see below) through iced redistilled water. Using the triangular testing methodology, 14 judges were selected on the basis of their olfactory acuity for dilute concentrations of pear essence. Twenty-five ml samples of freshly distilled water containing 4 and 8% of the trap solutions from the gas chromatographic fractionation (designated as "X") were compared against distilled water blanks (designated "O") using all possible combinations: XXO, XOX, XOO, OOX, OXO, OXX. Samples were presented at 9:45 A.M. in coded, covered wine glasses to judges seated in individual, partitioned booths. On each of 20 consecutive days, each judge received two sets and was asked to evaluate the odor as indicated in the score card illustrated in Table 2. The method developed by Roessler *et al (12)* was used to establish significant differences.

**TABLE 2**

**Pear aroma panel scoring card**

Name..... Date.....

Sniffing procedure:

1. Handle glass by stem, only.
2. Swirl contents in glass gently, remove lid, sniff, then replace lid.
3. Indicate below which sample is different and which sample(s) has the greater pear aroma.
4. Describe the aroma of each.
5. Samples may be re-sniffed as often as necessary.

| Sample number | Different sample | Greater aroma | Aroma description |
|---|---|---|---|
| ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... |

Although the actual concentration of the individual fractions presented to the panel is unknown, the relative concentrations are of the same order occurring naturally in the fruit. Consequently, these results should indicate the role played by each individual fraction in determining flavor acceptability of the pear.

## RESULTS AND DISCUSSION

Thirteen fractions were originally presented to the panel for analysis. The results (Table 3) combined with those of subsequent studies, indicate that frac-

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TABLE 3

Pear aroma panel results

| DEGS Fractions | % Conc. | No. Judges | % Correct | Sig | Description (in order of frequency) |
|---|---|---|---|---|---|
| | 4 | 24 | 79.2 | *** | Pleasant, sweet, weak |
| 1–5 | 8 | 13 | 92.3 | *** | Pleasant, sweet |
| 7 | 4 | 28 | 96.4 | *** | Pleasant, fruity, banana-pear |
| | 8 | 13 | 100.0 | *** | Pleasant, strong, banana-pear |
| 10 | 4 | 26 | 69.2 | *** | Pleasant, weak, banana-pear |
| | 8 | 13 | 100.0 | *** | Pleasant, banana, strong pear |
| 15–18 | 4 | 26 | 88.5 | *** | Unpleasant, pine-pear |
| | 8 | 13 | 100.0 | *** | Pleasant, strong, pine-pear |
| 19–21 | 4 | 28 | 67.9 | *** | Neither pleasant nor unpl., weak, pine-pear |
| | 8 | 14 | 85.7 | *** | Unpleasant, weak, pear-pine |
| 24 | 4 | 28 | 32.1 | | Extremely weak |
| | 8 | 14 | 57.1 | | Faint, pear-pine |
| 25–26 | 4 | 28 | 57.1 | ** | Very weak, sweet, pleasant |
| | 8 | 14 | 35.1 | | Very weak, delicate, pleasant |
| 27 | 4 | 28 | 42.9 | ** | Faint, unpleasant |
| | 8 | 14 | 50.0 | | Very weak, sweet |
| 28 | 4 | 26 | 100.0 | *** | Pear, pleasant, sweet |
| | 8 | 12 | 100.0 | *** | Pear, pleasant, strong |
| 29 | 4 | 26 | 69.2 | *** | Pleasant, weak, sweet, pear |
| | 8 | 12 | 91.8 | *** | Pleasant, sweet, pine-pear |
| 30 | 4 | 24 | 50.0 | | Very weak, pleasant |
| | 8 | 13 | 46.2 | | Sweet, pine-pear |
| 31 | 4 | 26 | 69.3 | *** | Pleasant, piney, pineapple |
| | 8 | 13 | 84.6 | *** | Pleasant, pine |
| | 4 | 24 | 75.0 | *** | Unpleasant, weak, pitch, pine |
| | 8 | 11 | 90.9 | *** | Pleasant, pine |

** Sig. at P = 0.01.
*** Sig. at P = 0.001.

tions 15–18, 19–21, and 27 are undesirable components, variously described as "pitch" or "piney." Fractions 24, 25, and 30 are evidently desirable, but in the natural pear they occur at such a low level that a significant portion of this trained panel failed to distinguish them from the distilled water controls at their normal level of occurrance.

Taste testing was done with canned pear nectar containing 5% sucrose, fortified with 1) fractions 2–10 and 28–31; 2) fractions 11–27; and 3) fractions 2–31 (control). Collections were made by conducting the effluent from a gas chromatograph through a short length of monel tubing to ice water traps. Some degree of unpleasantness was apparent in the flavor of each of these samples, although it was generally agreed that the samples containing additions of fractions 11–27 were most unpleasant. Judges familiar with oxidative defects characterized this off-flavor as "tallowy." During exploratory separations in this laboratory, it was observed that gas chromatography through copper columns gave atypical separations. It is possible that at least one of these components is an unsaturate, capable of a copper-catalyzed oxidation, and that both the essence recovery and subsequent examinations should avoid copper or copper containing alloys.

The curve shown in Figure 4 is typical of those obtained from a series of separate essence recoveries and extractions. In those fruits so far processed for essence recovery, there have been no striking differences in the relative amounts of different fractions, although the relative amounts of 20–21 were observed to reverse in one case. Assuming one could obtain representative samples, it would be interesting to compare fruits from different regions, and at different degrees of maturity, and follow the changes in the gas chromatographic curve.

These results suggest that pilot lots of pears could be steam distilled, extracted, and examined by gas chromatography to accurately evaluate the relative amounts of desirable and undesirable flavor compounds. This would permit selecting pears directly on the basis of flavor content, rather than some other measurable property that has been shown to correlate, in the average case, with dessert quality. Such a procedure would permit the grower to evaluate differences in various cultivation and harvesting practices. The canner could select pears on the basis of their flavor potential, ripen under conditions that produce maximal amounts of desirable and minimal amounts of undesirable flavor compounds, and process at the optimum flavor point. Large quantities of misshapen and irregular sized fruits, currently discarded, could be processed for essence recovery and puree. The essence so recovered could be used in fortification. An improved canned pear with strong consumer appeal is within our grasp.

## SUMMARY

By processing fresh, ripe pears in a specially designed enclosed system, aqueous essences with the typical desirable aroma of Bartlett pears have been recovered. Extracts of these have been fractionated by gas chromatography to some 32 fractions. Results obtained with a trained panel indicate that five of these contribute significantly to the desirable pear aroma, and perhaps four possess undesirable aromas. There are indications that copper or copper alloys can cause flavor degradation. Results permit the gas chromatographic curve to be interpreted as a "flavor spectrum" and suggest methods for accurately measuring the flavor content of pilot batches of fruit.

Because essence fortification markedly improves conventional pear purees, processing of cull pears for essence recovery might prove economically feasible.

### Acknowledgments

The authors are indebted to Mr. Harry Stein for supervising the essence recovery, and to Mrs. C. E. Squires and Miss Sandra Anton for technical assistance.

## LITERATURE CITED

1. Antoniana, C., Federico, L., and Serini, G. Correlation between content of 2,3-butylene glycol and acetylmethylcarbinol and the state of maturity of fruit. *Chimica (Milan)*, 9, 84 (1954).

2. Antoniani, C., and Serini, G. Correlation between content of 2,3-butylene glycol and acetylmethylcarbinol and the state of maturity of fruit. I. Pyrus malus. *Ann. sper. agrar.*, **9**, 1167 (1955).
3. Ash, A. S. F., and Reynolds, T. M. Water soluble constituents of fruit. III. An examination of the sugars and polyols of apricots, peaches, pears and apples by paper chromatography. *Aust. J. Chem.*, **8**, 276 (1955).
4. Burroughs, L. F., and May, Y. P. The composition of the juices of some varieties of cider apples. *Ann. Rept. Agr. Hort. Research Sta.* 1953. Long Ashton, Bristol.
5. Claypool, L. L., Leonard, S. J., Luh, B. S., and Simone, M. Influence of ripening temperature, ripeness level, and growing area on quality of canned Bartlett pears. *Food Technol.*, **12**, 375 (1958).
6. Hulme, A. C. Biochemistry of apple and pear fruits. *Advances in Food Research*. Vol 8. 1958. Academic Press, Inc., New York.
7. Kidd, F., West, C., Griffiths, D. G., and Potter, N. A. An investigation of the changes in the chemical composition and respiration during the ripening and storage of Conference pears. *Ann. Botany (London)*, **4**, 1 (1940).
8. Martin, W. E. Chemical study of ripening process of Bosc pears. *Botan. Gaz.*, **99**, 42 (1937).
9. Mehlitz, A., and Matzik, B. Zur Kenntis der in Obstsaften vorkommenden Fluchtigen sauren. *Obst. und gemseverwertung industrielle*, **41**, 227 (1956).
10. Pangborn, R. M., and Leonard, S. J. Factors influencing consumer opinion of canned Bartlett pears. *Food Technol.*, **12**, 284 (1958).
11. Phillips, J. D., Pollard, A., and Whiting, G. C. Organic acid metabolism in cider and perry fermentations. I. A preliminary study. *J. Sci. Food Agr.*, **7**, 31 (1956).
12. Roessler, E. B., Warren, J., and Guymon, J. F. Significance in triangular taste tests. *Food Research*, **13**, 503 (1948).
13. Serini, G. Correlation between content of 2,3-butylene glycol and acetylmethyl carbinol and state of maturity of fruit. II. *Ann. sper. agrar. (Rome)*, **10**, 857 (1956).
14. Simone, M., Claypool, L. L., Leonard, S. J., and Luh, B. S. Sweetness and acidity adjustment in canned Bartlett pears. *Food Technol.*, **13**, 727 (1959).
15. Strachan, C. C., Moyls, A. W., Atkinson, F. E., and Britten, J. E. Chemical composition and nutritive value of British Columbian tree fruits. Can Dept. Agr. *Publ. 862.* (1951).
16. Strain, H. Sources of D-sorbitol. *J. Am. Chem. Soc.*, **59**, 2267 (1937).
17. Tanner, H., and Rentschler, H. The composition of the fruit acids of Swiss fruit juices. I. The first acid of Swiss pear musts. *Mitt. Gebiete Lebensm. u. Hyg.*, **45**, 142 (1954).
18. Ulrich, R., and Thaler, O. On the presence and changes in several constituents of pears during the course of their development. *Compt. rend.*, **240**, 1625 (1955).
19. Valdes, R. M., Simone, M. J., and Hinreiner, E. H. Effect of sucrose and organic acids on apparent flavor intensity. II. Fruit nectars. *Food Technol.*, **10**, 387 (1956).
20. Widdowson, E. M., and McCance, R. A. The chemical composition of foods. Med. Research Council (Brit.). *Spec. Rept. Ser. 235* (1946).
21. Winkler, W. O. Report on decomposition of fruit and fruit products. *J. Assoc. Offic. Agr. Chem.*, **34**, 506 (1951).

# Effect of Pressure on Circulation Cleaning*

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(Manuscript received May 31, 1960)

In recent years, more and more food industries have begun to explore the advantages of in-place cleaning. These procedures generally involve cleaning of food handling equipment without disassembly, and apply the deterging medium by means of spray devices (cascade), high pressure jets (impingement), or recirculation through a closed system. The first two methods are generally used on tanks and vats; the third finds application to pipelines, plate heat exchangers, and other enclosed apparatus.

Although some segments of the food industries use these procedures widely, many of the fundamentals involved are not yet well understood. Gemmill *(4)* in pointing out the advantages of in-place cleaning, included savings in labor and detergent materials, lower bacteria counts in the product, and a lower incidence of equipment wear. Holland *et al (5)* studied various cleaning regimes under conditions approximating commercial operations, and made recommendations based on their observations. Cleaning effectiveness was followed by swab testing, with attention to both the number of bacteria, and the amount and type of soil picked up by the swabs. The authors noted a lack of correlation between bacterial counts and film deposits, and concluded that bacterial counts could not be recommended as the sole measure of cleanliness of lines cleaned in place. Calbert *(1)* concluded that satisfactory cleaning of pipelines could be achieved by starting with temperatures of 130–140° F, even though the solution cooled to as low as 90° F during the washing cycle. Smith and Roth *(12)* recommended temperatures ranging from 125–140° F and 160° F for circulating pipelines. For the more difficult job of circulating plate heat exchangers, Smith's *(11)* recommendations have gone as high as 190° F.

All of these authors have studied the cleaning of equipment under conditions approaching commercial operations, and each has reported conditons that will achieve "satisfactory cleaning." If this information were graphed with the y axis representing the amount of soil present and the x axis representing some variable or combination of variables, these results would comprise a single point showing that at some one value of x (end of the cleaning process), y equals zero. Whether y had just attained zero, or had been zero for some period of increasing x, would be unknown. Actually, the information would be more valuable if we know the *minimal* conditions necessary to satisfactory cleaning, because the influence of individual variables could then be studied. Investigations of this type require that the cleaning process be stopped short of completion, and are not adaptable to study in commercial plants. Also, it becomes necessary to determine with some precision the amount of soil that has been removed. While various methods for estimating soil removal have been investigated, the best results are achieved with radioactive tracers. Sieberling and Harper *(10)* found that soil deposits could be measured with greater sensitivity by radioisotope techniques than by bacteriological counts; Cucci *(2)* used radioactive phosphorus to measure soil deposits in tubings. Jennings, McKillop, and Luick *(9)* followed the rate of removal of dried milk films accomplished by various cleaning regimes by measuring the decrease in radioactivity of $P^{32}$ labeled soil films. Because these rates remained the same in *in vivo* and *in vitro* labeled material, they concluded the tracer was a satisfactory index of both organic and inorganic milk residues. Their results indicated that above Reynolds numbers of 25,000, turbulence became very important to the cleaning operation. Once this condition was realized test discs or strips in the center of the flow stream reflected cleaning conditions at the periphery of the inner pipe surface. Jennings *(6)* reported that better cleaning was achieved when the pump was positioned to pull the deterging medium through the system, so that the section to be cleaned was under reduced pressure. There were indications that this was due to the scrubbing action of entrained air, and it was demonstrated that controlled air leaks contributed to cleaning.

Jennings *(7)* later demonstrated that the phenomenon of cleaning could be treated from the standpoint of chemical kinetics, and that rate equations could be calculated for the over-all reaction. It was also demonstrated that the rate of soil removal is first order with respect to soil. This further points up the necessity of limiting soil removal studies to removal of ca 60% of the soil. To this point, a plot of soil vs time is essentially straight line—beyond this point, the relationship is non-linear. Equations that failed to take into account changes in reaction rate brought about by the decreasing soil concentration would be meaningless when applied to a single variable.

In this work, it was decided to investigate further the effect of pressure on cleaning of enclosed systems.

## METHODS AND PROCEDURE

**Standard soil films.** Standard soil films were prepared by adding sufficient (0.1–0.2 $\mu$l) $P^{32}$ phosphate solution to homogenized milk (100 ml) to give 8000–20,000 counts per min (Cpm) per ml. Stainless steel test discs, $1\frac{5}{16}$ inch diameter (permitting direct insertion into the counting chamber, below) were forced into counterbored rubber stoppers (Figure 1), so that the disc formed the bottom of a miniature vat. The stoppers were placed on a steam manifold, and 0.5 cc of radioactive milk was added. After being steamed to dryness, the discs were removed from the stoppers and allowed to stand overnight.

* This investigation was supported in part by research grant No. RG6778 from the National Institutes of Health, Public Health Service.

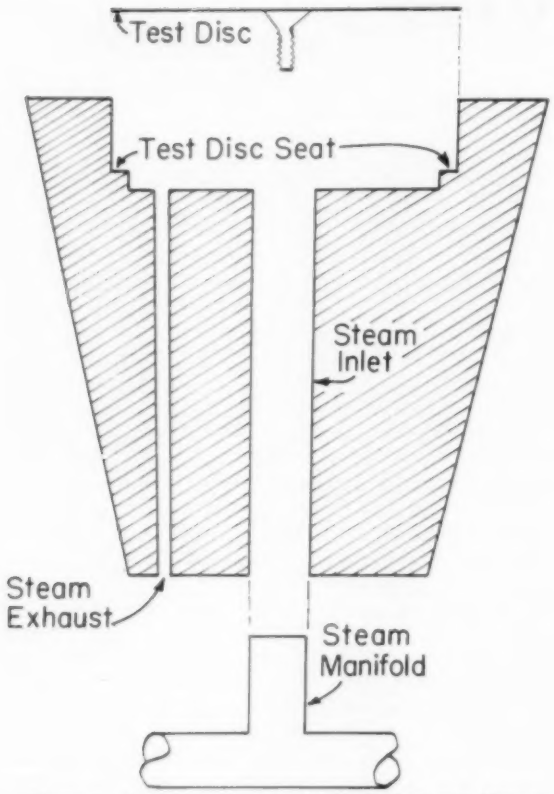



**Figure 1. Apparatus for depositing standard soil films on test discs.**

**Determination of radioactivity.** Radioactivities were determined with a thin window Geiger tube in a Tracerlab SC 9 E shielded manual sample changer. The discs fitted directly into the slide recesses. A Tracerlab SC 1000 scaler was used to record counts.

After standing overnight, the individual radioactivities of the test discs were determined by counting each for a period of one minute. The discs were subjected to the specified cleaning regime, and radioactivities redetermined with another one minute count. Per cent soil removal was taken as

$$\frac{\text{cpm, soiled disc} - \text{cpm, cleaned disc}}{\text{cpm, soiled disc}} \times 100.$$

The discs were then subjected to manual cleaning with 0000 steel wool before redepositing new soil films on them. Background counts were determined periodically on the manually cleaned discs, because $P^{32}$ apparently adsorbs to stainless steel *(10)*. When these counts exceeded 50 cpm, the discs were cleaned in nitric acid.

**Recirculating apparatus.** The test apparatus has been described elsewhere *(5, 6)*. Briefly, it consists of a 50-gal supply tank and a 3-HP 120-gal per min pump arranged to recirculate the supply tank solution. The unit has throttling valves on both the pressure and vacuum side, and the test section (described below) can be fitted into either the vacuum or pressure side.

The soiled test discs were bolted to brass plates (Figure 2) and the plates bolted together over a rubber spacing gasket that allowed the disc nuts to recess. This assembly, holding 40 test discs, was slipped into a 4-foot section of 1½ inch glass pipe. When installed, the test discs were in a vertical plane, and the pipe had a positive slope of ¼ inch per foot.

In calculating the Reynolds number, this unit was treated as

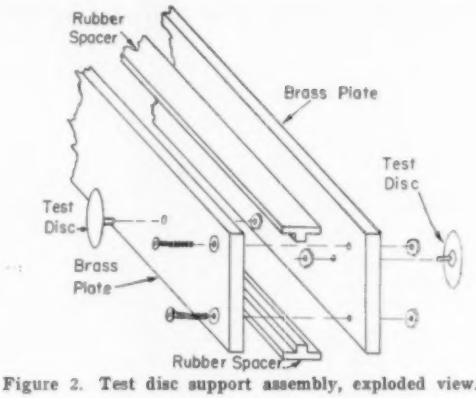



**Figure 2. Test disc support assembly, exploded view.**

if it divided the flow path into two parts. It has been previously shown *(9)* that this treatment is valid. Because the test disc support strips occupy a finite cross sectional area, it becomes necessary to correct for the increased velocity of the fluid flowing over the test discs. A throughput of 4.48 ft/sec, or 2.13 lb per sec, through the test section was selected, and achieved a Reynolds number of 100,000. This is equivalent to a flow rate of 5.34 ft/sec in a 1½ inch line, 1.375 inches i.d. The solution temperature was maintained at 160° F, and the deterging medium used in this study was water.

## RESULTS AND DISCUSSION

The realization that turbulence is important to circulation cleaning, and that turbulence can be increased by pumping larger volumes of solution, has led some to the conclusion that good cleaning demands a positive pressure within the system. A plot of the per cent residual radioactivity for discs cleaned at different pressures is shown in Figure 3. All other variables were constant. In this, as in other determinations of this type, a certain degree of scatter is apparent, but statistical analysis confirms that a relationship exists. The best-fit line, which was calculated by the method of least squares, is expressed by the formula $y = 0.02018x + 1.7764$. It is important to realize that pressure changes were accomplished by regulating the pressure and vacuum throttling valves to achieve the desired pressure without changing the amount of solution flowing through the system, as

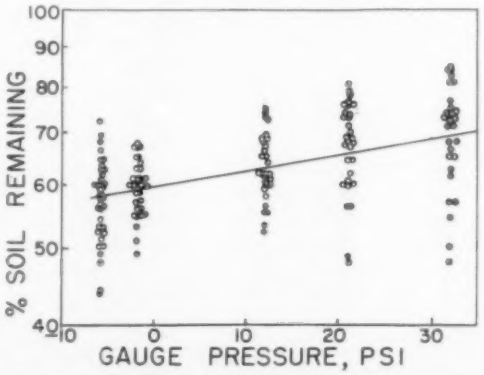
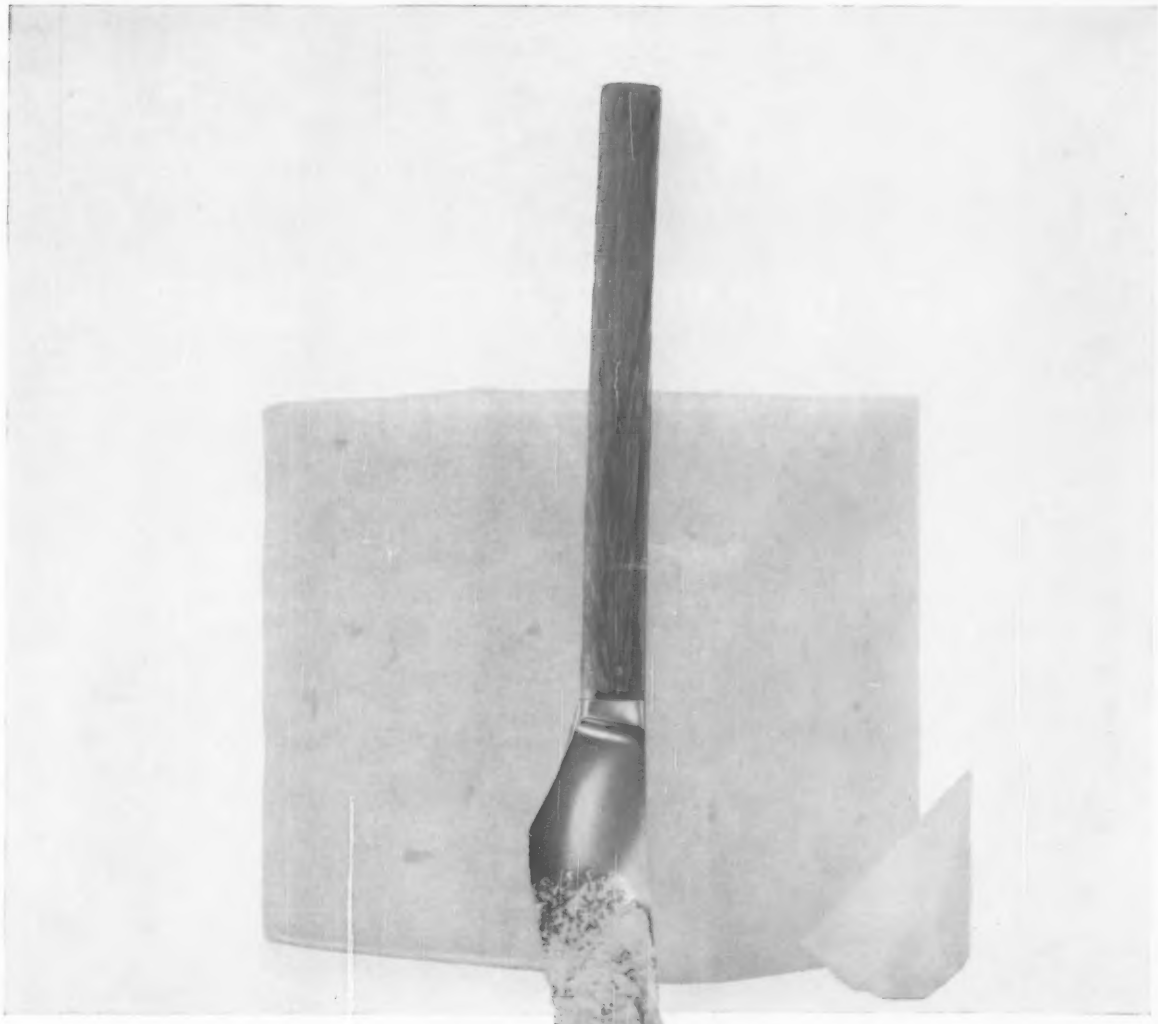



**Figure 3. Effect of pressure on rate of soil removal.**



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determined by weighing the discharge received over a given period of time.

Results indicate that not only is cleaning more efficient at reduced pressures, but that the increase in cleaning with decreasing pressure is a linear phenomenon, and not, as might be suspected, two horizontal lines breaking sharply at a gauge pressure of zero. These data support the suggestion that more attention should be given to pump placement in circulation cleaning. Reduced-pressure circulation is not, of course, applicable to use with high foaming detergents, because foam build up has been demonstrated to inhibit cleaning *(6)*. Similarly, it would be difficult to maintain any degree of vacuum at higher temperatures, due to the higher vapor pressure of the hot deterging medium. It is probable that the beneficial effect of vacuum on cleaning would be even more striking at lower solution temperatures.

Many food industries dealing with products where copper contamination can be a problem, have made great strides in replacing copper containing alloys with stainless steel. On converting to circulation cleaning, there is a strong tendency to use these discarded white metal lines for solution return. Dunkley and King *(3)* have shown that under these conditions, the copper in the white metal alloy becomes distributed through the system, adsorbs to the stainless steel in the product zone, and is available to contaminate the product.

## SUMMARY

Using radioactive soils, it is shown that the rate of soil removal by circulation cleaning is greater at lower pressures, and that the effect is linear. Thus, the cleaning efficiency of a circulation system can be increased merely by positioning the recirculating pump to pull, not push, the deterging medium through the area to be cleaned. The probable effects of higher solution temperatures and foaming detergents on reduced pressure cleaning is discussed.

### Acknowledgments

The author is grateful to D. R. DeValle and M. R. Sevenants for technical assistance.

## LITERATURE CITED

1. Calbert, H. E. Influence of water temperature and hardness on cleaning of CIP farm milk pipelines. *J. Milk and Food Technol.*, 21 (1) 12 (1958).
2. Cucci, M. W. Use of radioactive phosphorus to measure the amount of milkstone deposited on rubber, Pyrex glass, and Tygon tubings. *J. Milk and Food Technol.*, 17, 337 (1954).
3. Dunkley, W. L., and King, R. L. Adsorption of copper on stainless steel. *J. Dairy Sci.*, 42, 480 (1959).
4. Gemmill, A. V. Cleaning pipelines in place. *Food Eng.*, 27 (6) 59 (1955).
5. Holland, R. F., Shacl, J. D., Theokas, D. A., and Windlan, H. M. Cleaning stainless lines in place. *Food Eng.*, 25 (5) 75 (1953).
6. Jennings, W. G. Circulation cleaning. II. Effects of entrained air. *J. Dairy Sci.*, 42, 476 (1959).
7. Jennings, W. G. Circulation cleaning. III. The kinetics of a simple detergent system. *J. Dairy Sci.*, 42, 1763 (1959).
8. Jennings, W. G. Effective in-place cleaning. *Food Eng.*, 31 (10) 98 (1959).
9. Jennings, W. G., McKillop, A. A., and Luick, J. R. Circulation cleaning. *J. Dairy Sci.*, 40, 1471 (1957).
10. Sieberling, D. A., and Harper, W. V. Evaluation of cleanability of C.I.P. automatic valves. Paper M-46, 51st annual meeting, Am. Dairy Sci. Ann., 1956.
11. Smith, G. A. Efficient CIP cleaning-pasteurizers. Bulletin of the Technical Service Dept., Wyandotte Chemicals Corp., Wyandotte, Mich.
12. Smith, G. A., and Roth, A. A. Plant equipment cleaned in place. Bulletin of the Technical Service Dept., Wyandotte Chemicals Corp., Wyandotte, Mich.

# Fouling Inside Heat Exchanger Tubes[a]

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(Manuscript received May 31, 1960)

ACCUMULATION of cooked material on a metal surface used to heat a food can be a serious waste. Product quality is often affected and production rates are always reduced. The extent, or even the presence, of the problem may be overlooked. Since surfaces often foul very soon after start-up, the performance of clean surfaces may not have been observed for comparison *(7)*.

Fouling has been studied previously by comparing heat exchange rates at successive times since start-up *(1, 4)*. Change of over-all heat transfer coefficients is a similar approach *(8)*. Such experiments have lacked generality because only the resultant of many factors could be observed. For example, different temperatures exist at different points along a heat exchanger tube. The meaning of changes in the average heat flux in a long tube is therefore obscure. Furthermore, at any position lengthwise, the resistance to heat flow is distributed radially between convection of the condensate film outside the tube, conduction through the metal wall, conduction through the layer of foul, and convection through the fluid film inside the tube. Most of these resistances can be separately affected by varying conditions of operation. Often a heat exchange surface is changed permanently during removal of foul. This has made replication rare in fouling experiments. These three difficulties have been avoided in the present work. These results are valid for well-defined conditions, and can be applied to a practical case by calculation of suitable mean conditions. Only the results of down-flow inside a ¾ inch stainless steel tube 6 feet long are reported here. Most of the experiments involve boiling of tomato. A flow sheet is shown in Figure 1.

## EXPERIMENTAL

**Apparatus.** We wished to study factors affecting the flow of heat from steam condensing on the outside of a stainless-steel tube to a temperature-sensitive liquid flowing inside. In particular, we wished to know the resistance to heat flow from the inside wetted surface of the tube to the liquid passing over it. That is, heat flow and the temperature difference producing it must be measured in short regions under representative conditions. Calculation shows that on a stainless steel tube through which considerable heat is flowing, any temperature sensing device is necessarily located in an unrepresentative region. This is a result of the poor heat conductivity of stainless steel. The effect therefore persists, even if the liquid and steam flows could be left undisturbed.

Our solution was to convert the entire tube into a resistance thermometer *(5)*. An electric current was passed along the exchanger tube. Wires attached to the tube at various points

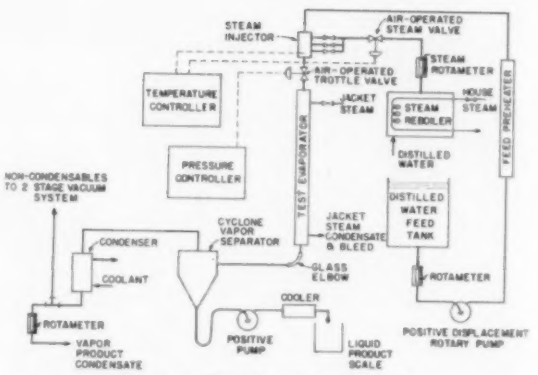


**Figure 1. Experimental equipment.**

allowed measurement of the voltage between them. These voltages reflected the resistivity of the stainless steel and therefore its temperature. Although the wires did disturb heat flow in their immediate vicinities, the voltage between any pair depended on the average metal temperature, not its point value. The device was calibrated by noting the voltages while the empty tube was surrounded by steam at various pressures. Under these conditions, the tube was substantially at the steam temperature. This arrangement allowed measurement of the temperature of the stainless steel tube wall half way in from either surface during operation of the exchanger.

In order to measure heat flux at any position, we used an effect long recognized in connection with electric power transmission lines. When an alternating current was passed along the exchanger tube, it tended to flow near the outside surface of the tube, as contrasted with the direct current, which was equally distributed throughout the tube wall cross section. This skin effect arises from the greater self inductance of the inner parts of a conductor compared with the outer parts. The outer surface of the tube was warmer than was the inner surface during normal operation. The A-C thermometer therefore reported higher temperatures than the corresponding D-C thermometer. This difference could be correlated with observed heat flux based on entering and leaving product rates and temperatures. See Figure 2. Using this technique, we could observe the average metal temperature and its associated heat flux at any place. Knowing the thickness and the thermal conductivity of the metal, we could calculate the inner surface temperature and the vapor fraction during operation.

It was also necessary to measure the inside liquid temperature in order to find the temperature difference associated with different rates of fouling. We fixed a ⅛ inch tube along the axis of the ¾ inch exchanger tube. A thermocouple junction was inserted in this inner tube with a slip fit. The junction could be moved along the bore of the heat exchanger so as to measure the temperature of the contents at any point.

The result of these arrangements was that we had a steam-jacketed stainless steel heat exchanger tube inside of which we could quickly measure the resistance to heat flow at various positions. Some observations of fouling made within this tube are now being reported. Various other experiments are planned for this unique apparatus.

**Method.** In order to observe fouling, the heat exchange surface had to be restored to the same condition after each experiment. The cleaning technique used was such that the surface was neither progressively scratched nor polished appreciably. The cleaning was repeated until the heat exchange

[a] Presented at the Twentieth Annual Meeting of the Institute of Food Technologists, San Francisco, California, May 18, 1960.

[b] A laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

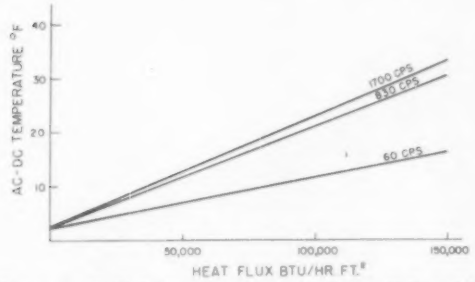


**Figure 2. Radial heat flux versus A-C less D-C resistance thermometer temperature.**

resistance reached a particular level when boiling distilled water.

For each fouling experiment the log of $h_L$, the coefficient of heat transfer from the wetted surface to the liquid, was plotted against time since cleaning. This value was extrapolated to zero time and taken as the coefficient for the clean surface under the conditions in question (Figure 3). The resistance at later times was assumed to consist of the sum of the clean surface resistance, $\frac{1}{h_0}$, and the resistance of the foul, $\frac{1}{h_F}$.

$$\frac{1}{h_L} = \frac{1}{h_0} + \frac{1}{h_F}$$

This involves the assumption that heat transfer would be the same from the foul surface and the clean metal surface if the temperatures were the same. Fouling rate is then calculated as the rate of change of $\frac{1}{h_F}$ with time. This rate is calculated for small regions over short periods of time. The particular units

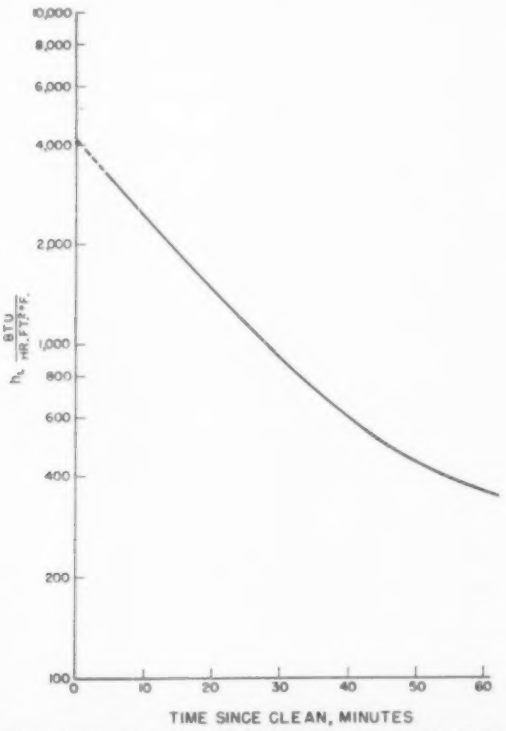


**Figure 3. Effect of fouling tomato paste on liquid heat transfer coefficients.**

are $\frac{\text{hr ft}^2 \text{ °F}}{\text{Btu min}}$. All these curves were constructed from numerous points which were considerably scattered. The data have been analyzed statistically *(5)*. The trends shown are those shown to be significant by this analysis. The curves shown represent about 90% of the data to within 20% with respect to fouling rate.

## RESULTS AND DISCUSSION

**Effect of temperature.** Temperature has by far the most important effect on fouling rate. In Figure 4,

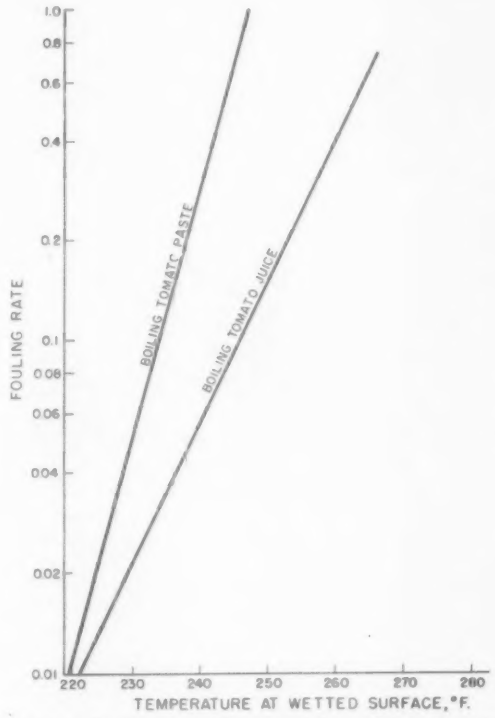


**Figure 4. Fouling rates of tomato juice and tomato paste.**

the rate of fouling of tomato is plotted against the temperature of the wetted surface for all vapor fractions. This temperature is calculated from the observed heat flux and the clean surface heat transfer coefficient. If these temperatures are plotted as reciprocals of the absolute temperatures, this figure would be in the form of the Arrhenius plot *(2)*. The slopes of the lines can then be interpreted as the activation energies of the reaction which produced the fouling. These values are 50 to 70 k cal/g mole. This is within the limits of the range of activation energies measured for the denaturation of proteins *(3)*. This supports the theory based on other evidence that protein denaturation is the initial cause of fouling by tomato and some other foods *(6)*.

**Effects of boiling.** Fouling is much more rapid when tomato paste is being warmed in contrast to when it is being boiled for the same wall temperature. This effect is shown in Figure 5. In this figure, the boiling curve is the same as the paste curve from

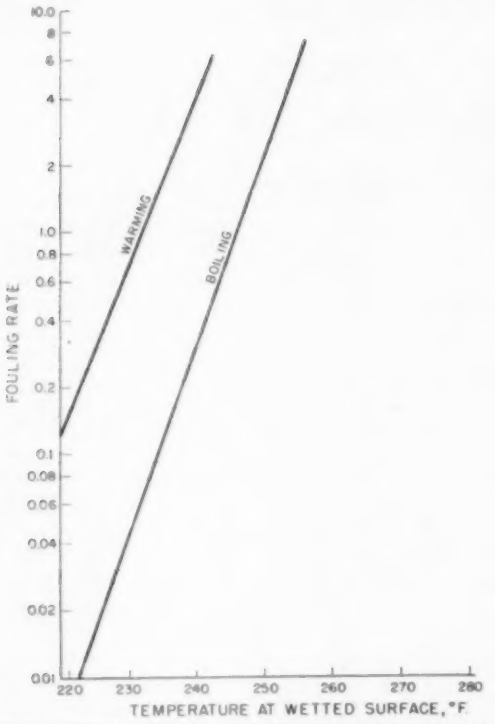


Figure 5. Effect of boiling on fouling rates of tomato paste.

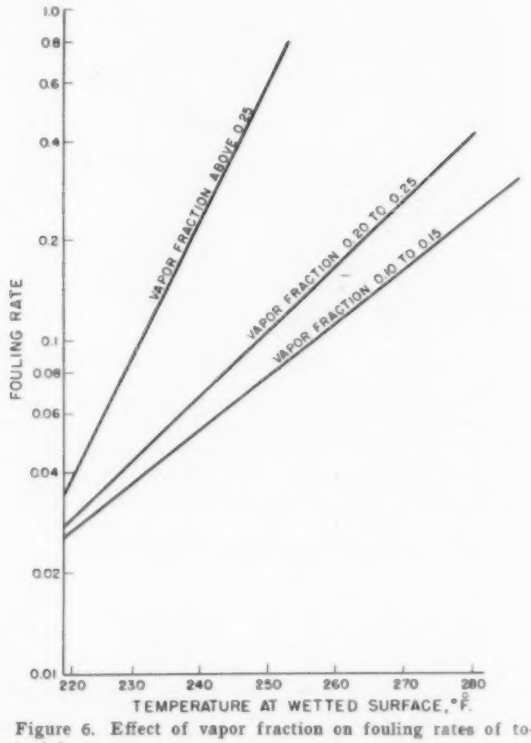
FOULING RATE
VAPOR FRACTION ABOVE 0.25
VAPOR FRACTION 0.20 TO 0.25
VAPOR FRACTION 0.10 TO 0.15
TEMPERATURE AT WETTED SURFACE, °F.

Figure 6. Effect of vapor fraction on fouling rates of tomato juice.

Figure 4. Due to this effect fouling can begin at the entrance to the tube of an evaporator where boiling had not yet begun. It could then spread to the remainder of the tube.

**Effect of vapor fraction.** As the weight fraction of vapor increases in any region, the rate of fouling increases (Figure 6). This effect does not become important until a fairly high vapor fraction, about 25%, is reached. This change may be stepwise, arising from abrupt changes in the mode of flow inside the exchanger as vapor fraction increases. Because of this factor, fouling can begin near the exit of an evaporator tube, where the vapor fraction is highest.

**Effect of viscosity.** Tomato paste fouls more rapidly than tomato juice (Figure 4). This is probably a result of the higher viscosity of paste. Synthetic solutions of low solids content but high viscosity show a marked fouling tendency.

A number of other factors were tested. The linear velocity, mass velocity, and heat flow rate did not have effects on fouling except through their relations to temperature and vapor fraction. Effects of tube diameter and direction of flow are still under study.

## SUMMARY

A fundamental study of fouling inside heat exchangers has been begun, with emphasis on tomato products. Fouling is increased with increasing wetted wall temperatures and reduced by boiling action in the liquid being heated. Of lesser importance is the increase of fouling with increasing vapor fraction and with increasing viscosity in the foulable liquid.

Various conclusions relative to heat exchanger design can be drawn. No considerable steam pressure can be used. Therefore ample tube area must be provided for any rated performance. Thermally saturated feed must be provided at the entrance to an efficient evaporator so that boiling occurs throughout the tubes. Therefore ample preheaters must be supplied. No high vapor fraction can be allowed inside an exchanger tube. Therefore an evaporator must include means of removing vapor, such as multiple effects or recirculation. Viscosity should be kept at a minimum. Therefore heat exchange should be to a liquid of as low solids content and as high temperature as possible.

## LITERATURE CITED

1. Badger, W. L., and Othmer, D. F. Studies in evaporator design. VIII. Optimum cycle for liquids which form scale. *Trans. AIChE*, **16** (II), 159 (1924).
2. Glasstone, Samuel. *Textbook of Physical Chemistry*. 2nd ed. 1946. Van Nostrand, New York, N. Y. p. 1088.
3. Johnson, F. H., Eyring, H., and Polissar, M. S. *The Kinetic Basis of Molecular Biology*. 1954. John Wiley, New York, N. Y. p. 271.
4. McCabe, W. L., and Robinson, C. S. Evaporator scale formation. *Ind. Eng. Chem.*, **16**, 478 (1924).
5. Morgan, A. I., and Carlson, R. A. Wall temperature and heat flux measurement in a round tube. *Trans. ASME*, paper 60-HT-1 (1960).
6. Morgan, A. I., and Wasserman, T. Fouling of evaporator tubes by tomato. *Food Technol.*, **13**, 691 (1959).
7. Morgan, A. I., Wasserman, T., Brown, A. H., and Smith, G. S. Commercial scale evaporation of tomato products in flash evaporators. *Food Technol.*, **13**, 232 (1959).
8. Tubular Exchanger Manufacturers Association. *Standards TEMA*. 3rd ed. 1952. New York, N. Y.

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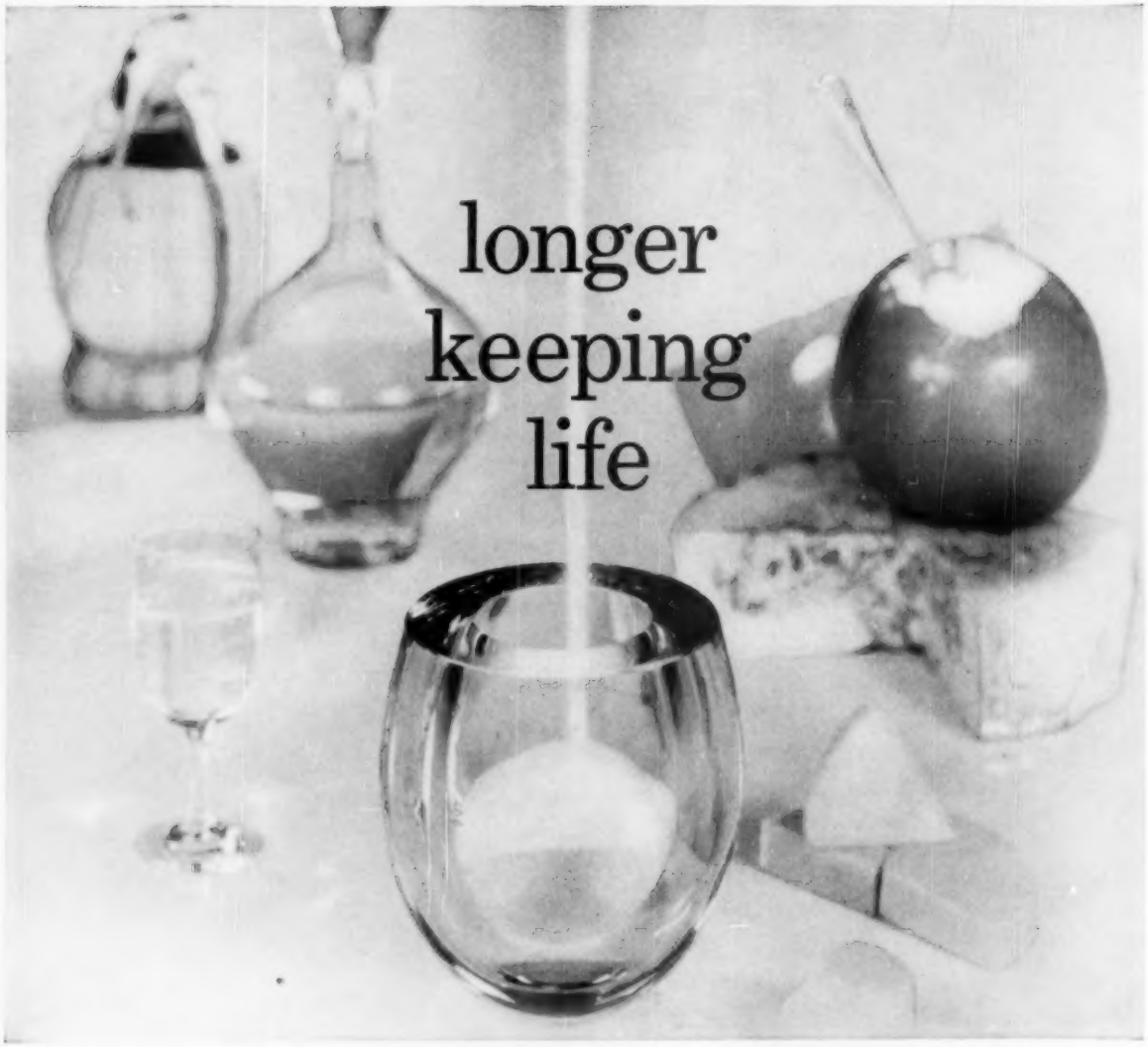


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# Roasted Coffee

## Color Measurement and Classification*

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(Manuscript received May 18, 1960)

No one has ever presented a technic for the measurement of roasted coffee color that could be considered for adoption as a standard for use throughout the coffee industry. No one has ever suggested a standard list of names for different colors of roast. Nor has anyone tried to associate a useful list of names with color values derived from a modern method of measurement.

This paper will describe a simple, rapid, and precise method for measuring the color of roasted coffee, develop a graded list of names applicable to colors of roasted coffee, and show the association between the two.

### EXPERIMENTAL

**Equipment.** Photovolt reflection meter, Model 610, with standard search unit, 610 Y, green tristimulus filter, gray working standard (19.5% reflectance) and glass cuvettes (1 3/16 inches diam, 1 inch depth, inside dimensions).

*Coffee grinders.* American Duplex Co., Model 494 G. Waring blender base and coffee mill attachment, without jar. A thin metal plate to cover mill when in operation. While the Duplex grinder was used in several experiments, the Waring equipment was finally selected for sample preparation because it is inexpensive and easily adjusted and cleaned. However, any comparable grinder that can be adjusted to give a grind, at least 60% of which will pass a U.S. No. 30 sieve, should be adequate.

*Cuvette coffee press.* This simple press was designed and built especially for this application. A solid plastic cylinder, 1 1/8 inches diam and 15/16 inch high was attached to the bottom of a triangular aluminum plate 1/8 inch thick. Each side of the triangle was 1 7/8 inches long. In each corner of the triangle was inserted a 9/32 machine screw 2 inches long. The screws, which formed a tripod were adjusted in height so that the distance between the bottom of the cylinder and the inside face of the cuvette was 9/16 inch. The legs of the tripod were fixed in position by tightening nuts above and below the plate. With this press ground coffee in the cuvette could be pressed to a constant depth of 9/16 inch.

A standard Coffee Brewing Institute coffee measure (volume, 2 level standard tablespoons), a metal tray (15 x 20 inches approx) on which the grinder was set to maintain some degree of cleanliness during sample preparation and a ten ounce glass or beaker to catch grounds during the mill cleaning operation.

Sieve shaking machine, W. S. Tyler, Ro-Tap with accessory equipment for making coffee grind analyses *(6)*.

#### Materials

*Coffee.* During the development of the standard method for color measurement, roasted coffee, both ground and beans from several commercial sources was used. Whenever experiments of a comparative nature were carried out, only coffee from a single source was used. Whenever necessary a grind analysis of material was performed.

To obtain information about the color of a wide range of coffee samples a request for beans roasted to various shades of brownness was sent to approximately 100 commercial roasters throughout the country. Responses from about 40 roasters were received. The samples were accompanied by descriptive names, to be listed below, corresponding to the degree of roast. They were ground as required. Some samples were received pre-ground and reground. All samples, whether in bean or ground, were reground to a standard particle size distribution which was finer than that of any sample received for color measurement.

**Method for measuring roast color.** The coffee mill was adjusted to give a grind having approximately 75% of the particles small enough to pass a standard U. S. No. 30 screen. To adjust the mill it was necessary to remove the stop screw that normally prevents the grinding plates from touching, to rotate the movable plate until it touched the stationary plate and then to back off the movable plate until 2 or 3 clicks were heard. Replacement of the stop screw then maintained the proper setting.

To obtain accurate readings on different samples run in sequence, it was necessary to etsablish a constant and uniform grinding procedure. After any sample was ground, the remains were brushed from the interior into the feed opening and scraped from the outlet. Starting the grinder removed most of the residue. Then two measures of the next sample were passed through the grinder to force out whatever remained in the burrs of the plates. If the small exit door is opened partially, the ground material is blown out with considerable force and can be collected in a waste container.

All samples were made representative by riffling repeatedly in a sample splitter. After the cleaning operation was completed one additional measure was transferred to the grinder bowl, a clean glass cuvette held directly below the exit, the grinder turned on, the cuvette filled loosely but uniformly to overflowing and finally leveled with the measure handle.

The filled cuvette was placed on the reflection meter search unit. The sample was then compressed to the standard thickness of 9/16 inch with the press and reflectance measured on the galvonometer. In all of this work the instrument was set to read 100 when the standard gray plaque, having a reflectance of 19.5%, was placed on the search unit containing a tristimulus green filter.

A second reading on the same sample was obtained by repeating the process *with a clean cuvette*. Cuvettes must be cleaned after each use.

Average reflectance readings, multiplied by 0.195 gave absolute reflectance.

### RESULTS AND DISCUSSION

**Development of the method.** The method described above is the result of many trials by which elimination of factors contributing to excessive variation and simplification of equipment and procedure were possible. The factors affecting precision that soon became apparent were particle size of the grind, diameter of the sample cuvette, pressure on the sample in the cuvette, method of filling the cuvette, and cleanliness of the cuvette. Typical experiments illustrating these points follow.

The loose filling of cuvettes could not be controlled adequately nor could any degree of hand pressure without some guide. Consequently, the hand cuvette press was designed and built (Figure 1). Its adjustable screw legs permit packing of a uniformly filled cuvette to any depth desired. However, as depth is related to pressure, variations in depth will give dif-

* Presented at the Twentieth Annual Meeting of the Institute of Food Technologists, May 25, 1960, San Francisco, California.

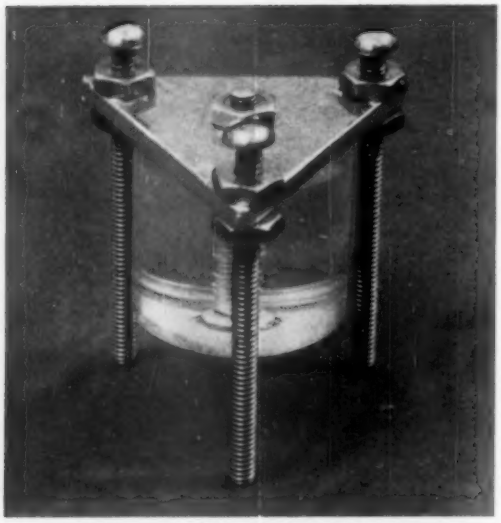

**Figure 1. Coffee cuvette hand press.**

ferences in reflectance. The analysis of data shown in Table 1 demonstrates how critical a variation of $\frac{1}{16}$ inch of bed depth is in the measurement of reflectance. It is, however, simple to control the pressure and the way in which the reflective surface is prepared.

**TABLE 1**

**Effect of pressure on the reflectance of roasted ground coffee**

| | Reflectance after pressing constant initial volume to depth of | | |
|---|---|---|---|
| | $\frac{8}{16}$ in | $\frac{9}{16}$ in | $\frac{10}{16}$ in |
| Average 6 tests | 5.88 | 5.57 | 5.31 |
| Standard deviation | 0.12 | 0.07 | 0.11 |
| "t" value | 5.2[1] | | 4.6[1] |

[1] Differences significant at 1% level.

The diameter of the sample holder is also critical. For example, the analysis presented in Table 2 shows that a difference of $\frac{1}{16}$ inch in cuvette diameter will cause a significant difference in reflectance, when the same press is used to compact samples. This difference should not occur, however, if the body of the press is made to conform closely to the diameter of the cuvette. The difference between the diameters of the hand press and the cuvette should not be more than $\frac{1}{16}$ inch.

**TABLE 2**

**Effect of change in cuvette diameter on the reflectance of roasted ground coffee**

| | Reflectance of samples in cuvettes[1] | |
|---|---|---|
| | $1\frac{3}{16}$ inch diam | $1\frac{4}{16}$ inch diam |
| Average 10 tests | 5.64 | 5.52 |
| Standard deviation | 0.10 | 0.12 |
| "t" value | 2.33[2] | |

[1] Loose filled cuvettes pressed to depth of $\frac{8}{16}$ inch.
[2] Difference significant at 5% level.

The variation in reflectance associated with grind has already been mentioned. However, if the Waring coffee mill were to be used for sample preparation, it was necessary to determine within what limits of adjustment it would yield grinds for which reflectance would be constant. In Table 3 are presented data showing the relationship between grinder plate setting, grind analysis, and reflectance. If the plates are set at 2 or 3 stops from a fully tight position, the grinds will be quite fine; approximately 60% or more will pass through a U. S. standard No 30 screen. If the grind is at least as fine as this, the reflectance values will be constant. As the grind becomes coarser, the reflectance values increase. Other tests showed that pulverized grinds, those which are ground so finely that all of the sample would pass through the No 30 screen, gave slightly lower reflectance values.

**TABLE 3**

**Interrelationship of grinder setting, grind analysis and reflectance**

| Plate setting Stops from tight position | Grind analysis % thru 30 sieve | Reflectance Y[1] |
|---|---|---|
| 2 | 76 | 5.53 |
| 3 | 62 | 5.52 |
| 4 | 54 | 5.62 |
| 5 | 42 | 5.82 |

[1] Average of 6 tests at each position. Loose filled cuvettes pressed to a depth of $\frac{9}{16}$ inch.

Because sample of roasted coffee may be received as beans or already ground it was necessary to determine whether single pass grinding of beans and regrinding of ground coffee to the degree of fineness required for the measurement would alter reflectance. It was found (Table 4) that beans ground first to contain 30% fine material then reground to about 75% fines gave the same reflectance as beans ground in one pass through the mill to 75% fines. This indicated that any commercial sample could be treated as recommended.

**TABLE 4**

**Effect of grinding beans and regrinding pre-ground roasted coffee on reflectance**

| Starting grind % thru 30 sieve | Final grind % thru 30 sieve | Reflectance Y[1] |
|---|---|---|
| Fine—30 | 80.5 | 5.72 |
| Beans—0 | 75.0 | 5.68 |

[1] Average of 6 tests; loose filled cuvettes pressed to depth of $\frac{9}{16}$ inch.

Cuvette cleanliness is also extremely critical. Preliminary experiments seemed to indicate that a cuvette could be used for the measurement of reflectances of duplicate samples. However, as the work progressed, it became evident that the first reading was lower than the second almost constantly. Although the difference in reflectance was less than 0.2 of 1% there was sufficient evidence to recommend that cuvettes be thoroughly cleaned and dried after each use.

Several studies *(2, 3, 4, 5)* that were basic to the development of the method described above have been carried out by Mackinney and his associates. They have published important and useful information on the relationship between color and color development

in varieties of coffee beans and temperature, rate of heat input, particle size of grind and flavor. In particular they have reported very critically on the capabilities of several reflectance measuring instruments. Of these the Photovolt reflection meter was selected as most suitable for routine laboratory use. Little *(1)* has recently reported the results of a collaborative study in which six of these instruments have been compared. Each instrument, although precise, differed slightly but significantly from the others. As this would probably be true also of other types of instruments, it is necessary that inter-laboratory results be correlated with a standard instrument or calibrated against standard color samples. Problems associated with standard roasted coffee samples are now under consideration.

**Precision of the method.** The precision of the method was estimated by two approaches. First, by analysis of differences between a number of measurements made in duplicate and second, by comparison of sample ranking by the instrument and by human judgment.

Two samples of coffee having reflectance values of 5.00 and 5.93% were mixed with each other in such a way that a graded series of 11 samples, adjacent members of which differed by about 0.1%, was obtained. By measuring the reflectance of each member in duplicate and in two separate tests a total of 22 differences was cumulated. The average difference was 0.45 scale units; the standard deviation, 0.34 units. These, converted to reflectance, were 0.09 and 0.07, respectively. These values permit the interpretation that approximately 8 shades of color may be differentiated within each percentage unit of reflectance with a certainty of 95%.

Actually, the measurements on these samples showed that the instrument had no difficulty in separating or ranking correctly all eleven. On the other hand, when this same series of samples was randomly shuffled and presented to 7 different judges for ranking, not one of the judges was able to make a correctly ranked arrangement. Although the correlation coefficients *(7)* for the 7 judges, which were 0.95, 0.90, 0.85, 0.94, 0.88, 0.61 and 0.95, showed a highly significant ability of the judges to differentiate shades of roast color within a very small range, this test also demonstrated that the judges were more fallible than the instrument. Further study in progress will show more exactly how many shades of color the average human eye is capable of differentiating within one percentage unit reflectance.

**Classification of roasted coffee color.** There is no standard or uniform classification of roasted coffee color. In order to get some information about the terminology used in the coffee industry a request for coffee samples, running the whole range of color, was sent to about 100 roasters throughout the country. Replies, which included samples and the terms applied to the different roasts, were received from about 40. Some roasters said that because they were already using an instrumental technic, they no longer used names to designate roast color, only numbers. These numbers would have no meaning outside each organization because of variations in technic used to obtain them. Other roasters had designated the color according to brand name. These also would be meaningful only to the organizations following this practice.

The terms for roast color that were submitted were many and except for one group had really no close connection with degrees of color intensity. For example, such terms as *Boston, French, Italian, Spanish, Greek, New York* and *Cuban* give no indication of color and would certainly vary according to the experience of individual roasters. The same interpretation applied to a group of miscellaneous terms such as *regular city, full city, normal, regular, full, heavy, whole, special, standard, high* and *cinnamon.* Some were also identified by the temperature of the beans in the equipment at which the roasting process was stopped. The only terms that had any relation to color were grouped as *very light, light, medium, dark, golden dark* and *very dark.*

To construct a useful scale it was necessary to determine the limits within which all possible shades of color that might be encountered in commercial roasting would lie. Examination of the data obtained from the samples submitted showed the lighest roast had a reflectance of 10.29 and the darkest roast a reflectance of 2.54 per cent. It was then relatively simple to devise an 11-point scale as shown in Table 5.

TABLE 5

Classification of roasted coffee color by class and percent reflectance

| Class group | Eleven-point descriptive scale | Class limits per cent |
|---|---|---|
| 1 | Extremely dark | 0–1 |
| 2 | Very dark | 1–2 |
| 3 | Dark | 2–3 |
| 4 | Dark medium | 3–4 |
| 5 | Medium-dark | 4–5 |
| 6 | Medium | 5–6 |
| 7 | Medium-light | 6–7 |
| 8 | Light-medium | 7–8 |
| 9 | Light | 8–9 |
| 10 | Very light | 9–10 |
| 11 | Extremely light | 10–11 |

The 11 percentage points are associated with homogeneous designations that are associated naturally with color intensity. The lightest sample referred to above would be, on this scale, an extremely light roast; the darkest, a dark roast.

Space does not permit the inclusion of every datum derived from this study but it was obvious that each roaster was using some judgment, visual or subjective in this case, but each was different from every other. As noted earlier, the instrumental technic could easily differentiate at least 8 and possibly 10 shades of color within each percentage unit of reflectance; the human eye, sensitive as it is, could perhaps differentiate a smaller number of shades within the same interval. However, human judgment included no real sense of scaling. Class distinction was in some instances based on wide reflectance limits and, in other instances, on small ones. Lack of uniformity in color scaling was quite apparent within a single scale and within all that were used. In any case, there was certainly no way of relating the terminology of one roaster with

that of another. Clearly there was an opportunity for some standardization, if not for understanding individual roaster operation, at least for intra-industry communication.

**Color of commercial retail ground coffee.** With the technic described above it was possible to begin an analysis of the color problem as it exists throughout the country. Up to the present time, 47 samples of commercial retail ground coffee have been examined. The results (Table 6) show that 43 of these samples

TABLE 6
Color of commercial retail ground coffee

| Class limits per cent | Description | Total | East | Central | West |
|---|---|---|---|---|---|
| 3–4 | Dark-medium | 2 | 2 | 0 | 0 |
| 4–5 | Medium-dark | 0 | 0 | 0 | 0 |
| 5–6 | Medium | 16 | 9 | 2 | 5 |
| 6–7 | Medium-light | 27 | 6 | 8 | 13 |
| 7–8 | Light-medium | 1 | 1 | 0 | 0 |
| 8–9 | Light | 1 | 0 | 0 | 1 |
| | | 47 | 18 | 10 | 19 |

(93%) gave reflectance values that fell within the medium and medium-light classes. The roast color of coffee throughout the country does fall within fairly narrow limits. Two of the samples, those that gave values falling in the dark-medium class, are called after-dinner or espresso-type coffees. It is noteworthy that there is apparently a very definite distinction between the roast color of espresso coffee and the normal every-day coffee.

These few data were examined to determine whether there might be some truth to the opinion that Eastern coffee is roasted more darkly than Western coffee. As 60% of the Eastern coffee was classified as medium and 73% of the Western coffee as medium light, it may be tentatively stated that Eastern coffee is darker than Western coffee. It is also darker than Midwest coffee. Whether these differences will hold after a more extensive series of samples has been analyzed remains to be seen. Furthermore, whether the color difference, if it actually exists, has an important bearing on consumer acceptance is a problem that can now be attacked using the instrumental technic as a sensitive control on color evaluation.

## SUMMARY AND CONCLUSIONS

A method for measuring the color of roasted coffee has been developed. The influence of factors critical to precision has been studied. The precision of the method has been estimated and found to be greater than human subjective evaluation of color. This method is presented to the coffee industry for consideration as a basis for uniform and standard evaluation of roast color.

Numbers derived from measurement have been correlated with an attribute-intensity scale which provides uniform terminology as a replacement for the wide variety of terminologies now used by industry.

A study of commercial retail roasts of coffee revealed that there is a sharp differentiation between normal and espresso-type roasts. Midwestern and Western coffees appear to be somewhat lighter than Eastern coffees.

### Acknowledgment

The Coffee Brewing Institute thanks its many friends in the coffee industry for their interest and participation in this study and the Evans Research and Development Corporation for permitting the use of its facilities for a portion of the work.

### LITERATURE CITED

1. Little, A. C. Collaborative study of the measurement of color of ground coffee. *Tea and Coffee Trade Journal*, March 1960, p. 18. Coffee and tea industries and the flavor field, *loc. cit.*, March 1960, p. 21.
2. Little, A. C., Chichester, C. O., and Mackinney, G. On the color measurements of foods. *Food Technol.*, 12, 403–409 (1958).
3. Little, A. C., Chichester, C. O., and Mackinney, G. On the color of coffee. II. *Food Technol.*, 12, 505–507 (1958).
4. Little, A. C., Chichester, C. O., and Mackinney, G. On the color of coffee. III. Effect of roasting conditions on flavor development for a given color. Role of initial moisture level on roasting characteristics of green coffee beans. *Food Technol.*, 13, 684–688 (1959).
5. Little, A. C., and Mackinney, G. On the color of coffee. *Food Technol.*, 10, 503–506 (1956).
6. Lockhart, E. E. The Analysis of Coffee Grinds. Pub. No. 32. April 1958. Coffee Brewing Institute, N. Y.
7. Moroney, M. J. *Facts from Figures.* 2nd ed. 1953. Penguin Books, A 236. London.

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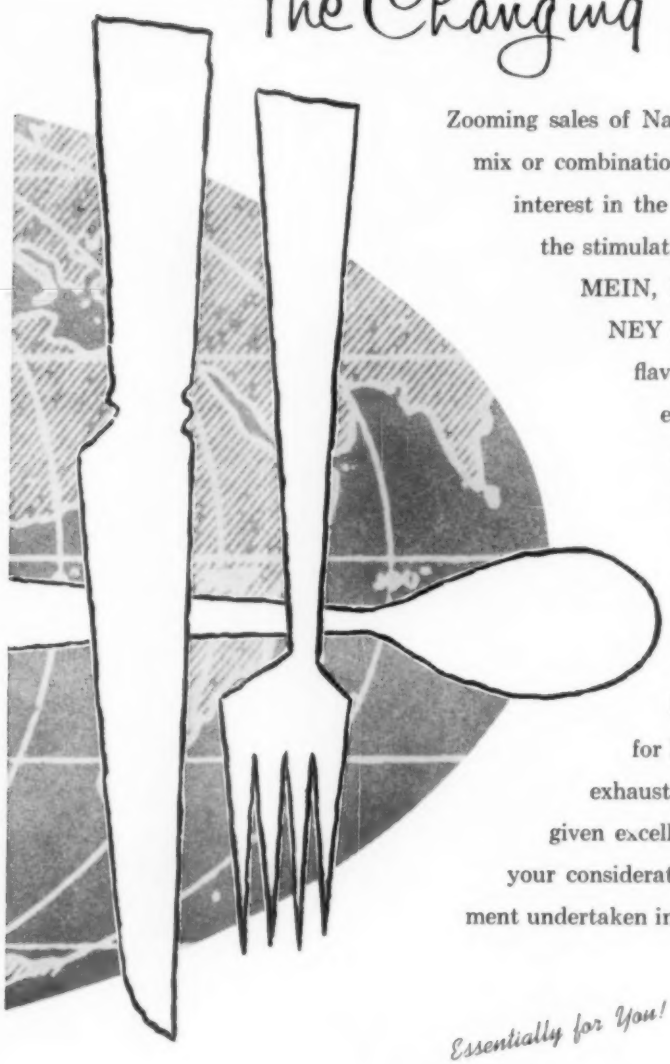

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# Investigation of Equivalent Weights of Dehydrated Vegetables in Comparison to Their Fresh Conventional Counterparts. 1.

## Dehydrated Sliced Onions

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Food Science and Engineering Division, U. S. Naval Supply Research and Development Facility, Bayonne, New Jersey

(Manuscript received May 18, 1960)

THE EQUIVALENT WEIGHT[a] of a dehydrated vegetable compared to its fresh, conventional counterpart must be known not only for cooking purposes but also as a basis for all logistical calculations. Where use of the vegetable is extensive, the accuracy of the ratio assumes vital importance. Such comparisons as space-savings, weight-savings, costs, and procurement requirements, among many others, are dependent upon this figure.

One extensively used vegetable where this ratio is of particular concern is dehydrated sliced onions. Published information on equivalent weights was found to be varied and often confused with rehydration ratios. One manufacturer claimed that one pound of dehydrated sliced onions would equal 25 pounds of fresh onions. In published recipes and other sources *(1, 3, 5)*, ratios ranging from 1:1.3 to 1:10 were found in use.

Because of the importance of its accuracy, a study was conducted on the use of dehydrated sliced onions to determine a practical equivalent weight ratio. Preliminary surveys have also indicated that the equivalent weight ratios of other dehydrated vegetables are equally varied. Investigations are presently being conducted on dehydrated diced potatoes and dehydrated potato granules. The results of these investigations will be reported at a later date.

### PRELIMINARY SURVEY

A preliminary survey established the fact that onions are one of the most extensively used food items in feeding operations *(5)*. Most main dishes, soups, sauces, gravies, and salads make use of this vegetable in one form or another. They are used both raw and in the cooked state. In a number of uses, onions are the chief ingredient forming the greater part of the bulk and in which the onion flavor predominates. In other uses, onions are added in small quantities as a seasoning blended in with other ingredients. In still another use, they are applied as a garnish to another main ingredient or salad.

Except where whole onions are used, the dehydrated sliced form substitutes more than adequately for the fresh. Where raw onions are used, rehydration alone is needed in the preparation. Where further cooking is called for, the dehydrates must be rehydrated separately and then cooked as called for in the recipe. In some uses, where liquid content is high, dehydrated sliced onions may be added directly and cooked along with other ingredients without separate rehydration and cooking steps. All of these factors, together with the frequency and the amounts used, were considered in the experimental plan of investigation.

### EXPERIMENTAL

The dehydrated sliced onions were procured from military stock conforming to Federal Specification JJJ-0-533 (August 8, 1956), with moisture content specified as 4% by weight. All samples tested were used within 2 years of date of pack.

The rehydration properties were investigated by soaking the dehydrates in uniform quantities of water at various temperatures, each for 30-min periods. Judgments were then made on the acceptability and the condition of the rehydrated products.

A series of experimental tests were then conducted to compare the properties of fresh conventional and dehydrated sliced onions prepared in similar recipes. Where onions were used in the raw state, the dehydrated onions were merely rehydrated and then used as indicated in the recipe. Where cooking was required, the dehydrated onions were rehydrated separately and then prepared as required in the recipe. The initial quantities of both fresh and dehydrated onions (and other ingredients) were adjusted so that yields of both were 100 portions of finished product. Acceptability tests were conducted on the finished products to determine the adequacy of recipes from the taste standpoint. Comparisons of the amount of onions used were then made to determine the equivalent ratio used in each recipe.

Frequency of use and the total amount of onions used in all forms were determined by conducting a survey of suggested menus for four 30-day periods *(2)*.

### RESULTS AND DISCUSSION

**Rehydration ratio.** The rehydration ratios at all temperatures were found lower than those indicated by manufacturers and most published information. Where it was generally agreed that 1 lb of dehydrated sliced onions will yield 5 lb of rehydrated product, none of the test results approached this ratio, except at elevated temperatures (Figure 1). Onions rehydrated at temperatures above 110° F, however, were not considered as satisfactory as onions rehydrated at lower temperatures. At the higher temperatures, the products were limp and lacking in color and taste. The water used for rehydration smelled strongly of onions, suggesting that a good part of the flavor had dissipated in rehydration at this temperature. Onions rehydrated at lower temperatures, however, were more crisp in texture and resembled the fresh more closely

[a] Since dehydrated onions are used (a) in the raw state after rehydration only, and (b) in the cooked state after rehydration and then cooking as required in the recipe, the distinction is made between "equivalent weight" and "rehydration ratio." "Equivalent weight," as used here, refers to the amount or ratio of the dehydrate substituted for the fresh in the final recipe, either cooked or raw. The "rehydration ratio" refers to the ratio of the dehydrate resulting after rehydration only. The two values are not necessarily the same.

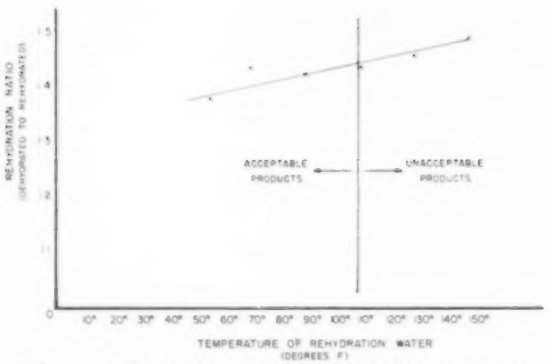


**Figure 1. Rehydration ratios of dehydrated sliced onions at various water temperatures.**

in appearance and flavor. The most satisfactory products were found after rehydration in a range of temperatures from 70° F to 110°, with an average ratio of 1 : 4.3.

**Equivalent weights.** The rehydration ratios, however, were found applicable only where the rehydrated onions were to be used in this state without cooking. The series of experimental recipe tests showed that the equivalent weight ratio differs from the rehydration ratio where cooking is involved. In addition, the equivalent weight ratio itself changes with the amount of liquids in the recipe. This effect appears to be similar to that found by Hunt and Matheson *(4)* in comparing the cooking properties of dehydrated fish and meats.

Table 1 shows the two distinct ratios found in recipe testing. (Each recipe produced acceptable products with the desired 100-portion yield.) One ratio was found suitable for products such as fried onions; the other for creamed onions.

The explanation for the different ratios where different cooking is involved appears to be due to the amounts of aqueous liquids used. In creamed onions, ample liquid was present in the recipe to inhibit loss of moisture from the reconstituted onions during cooking. In fried onions, no liquid was present other than small amounts of shortening. With no liquids to inhibit it, moisture was driven off freely. Consequently, shrinkage was greater and the bulk yield less.

The rehydration ratio of 1 : 4.3 appeared to differ from the equivalent weight ratios of 1 : 6.1 for fried onions and 1 : 5.4 for creamed onions because of the differences in the moisture content of fresh onions and rehydrated onions. This was evident during the frying tests. Table 2 shows that appreciable amounts of liquids were left after frying onions in a steam-jacketed kettle, whereas practically no liquids were left after the rehydrated onions were fried. An average moisture loss of 27.7% was found after frying the fresh onions as compared to 14.1% after frying the rehydrated onions. This suggested that the dehydrated onions did not rehydrate fully to their previous natural state and thus contained less moisture in comparison to the fresh.

**TABLE 1**

**Equivalent weight ratios of dehydrated sliced to fresh onions under different cooking conditions**

| Recipe | Weight of raw dehydrated or fresh peeled onions used in recipe | Cooked yield* | Equivalent wt ratio of dehydrate to fresh peeled onions |
|---|---|---|---|
| Fried Onions | Dehydrated 5.25 lb<br>Fresh 32.0 lb | 100 portions<br>100 portions | 1 : 6.1 |
| Creamed Onions | Dehydrated 3.00 lb<br>Fresh 10.2 lb | 100 portions<br>102 portions | 1 : 5.4 |
| Raw Onions | Dehydrated 1.00 lb<br>Fresh 4.3 lb | x<br>x | 1 : 4.3 |

* One portion equals ½ cup (4 fl oz).

**TABLE 2**

**Comparison of yields and moisture losses in frying dehydrated sliced onions and fresh onions**

| | Raw material | Weight reconstituted | Cooked yield | Per cent cooked yield[1] | Liquids drained |
|---|---|---|---|---|---|
| Exp 1 | | | | | |
| Dehydrated | 2 lb | 9 lb. 3 oz | 8 lb 0 oz | 87.0 | (none) |
| Dehydrated | 2 lb | 9 lb 0 oz | 8 lb 0 oz | 84.9 | 4 fl oz |
| | | | Average | 85.9 | |
| Exp 2 | | | | | |
| Fresh | 9 lb | X | 6 lb 11 oz | 74.4 | 40 fl oz |
| Fresh | 9 lb | X | 7 lb 4 oz | 80.3 | 28 fl oz |
| | | | Average | 77.3 | |

[1] Per cent yield of reconstituted weight where dehydrates were used; per cent yield of raw material where fresh onions were used.

**Logistical equivalent weight ratio.** While the preceding ratios clarified the substitution of onions in individual recipes, they did not express an over-all average ratio for logistical calculations. Any such determination must, of necessity, take into consideration the manner in which onions are normally used, and the amounts used. This can only be determined by a survey of the normal uses of onions.

In a survey of suggested menus for a representative 4-month period in the *Navy Food Service Bulletin (2)*, approximately 145 recipes called for onions in one form or another. Of these, however, only 32 were found which used onions in sufficient quantity and frequency to be considered; the remaining recipes were seldom used or called for onions in extremely small quantities.

Table 3 lists the 32 recipes, the quantity used in each recipe, frequency of use, and the total weight of onions used in each recipe during the 4-month period. By using the appropriate equivalent weight ratio or the rehydration ratio, the equivalent weight of dehydrated onions in each recipe was then determined. Dividing the total weight of fresh onions normally used in these recipes by the total amount of dehydrated onions substituted resulted in a ratio of 1 : 5.38. Since this represented raw, peeled onions, taking into consideration average peel losses of 10%, the final ratio of 1 : 5.98 was considered to represent the average substitution of dehydrated sliced onions for fresh for all logistical calculations.

TABLE 3

**Determination of average equivalent weight ratio based on frequency of use during July, October (1959), January and April (1960) (2)**

| Recipe (3) | Wt per recipe (lb) | Freq of use | Total wt (lb) | Use ratio | Equiv wt. of dehydrate (lb) |
|---|---|---|---|---|---|
| Fried onions | 32 | 4 | 128 | 1:6.1 | 21.33 |
| French onion soup | 6 | 15 | 90 | 1:5.4 | 16.67 |
| Raw onions | 10 | 8 | 80 | 1:4.3 | 18.60 |
| Glazed onions | 25 | 3 | 75 | 1:5.4 | 13.89 |
| French fried | 18 | 4 | 72 | 1:6.1 | 11.80 |
| Baked hash | 5 | 11 | 55 | 1:5.4 | 10.19 |
| Yankee pot roast | 5 | 9 | 45 | 1:5.4 | 8.33 |
| Braised steak w/sm onions | 16½ | 2 | 33 | 1:6.1 | 5.41 |
| Cucumber and onion salad | 8 | 4 | 32 | 1:4.3 | 7.44 |
| Cream of chicken soup | 1½ | 19 | 28.5 | 1:5.4 | 5.28 |
| Vegetable soup | 14 | 2 | 28 | 1:5.4 | 5.19 |
| Braised beef chunks | 5.5 | 4 | 22 | 1:6.1 | 3.61 |
| Spaghetti sauce | 5 | 4 | 20 | 1:5.4 | 3.70 |
| Meat balls | 3 | 5 | 15 | 1:6.1 | 2.46 |
| Hot potato salad | 4½ | 3 | 13.5 | 1:5.4 | 2.50 |
| Cooked vegetable salad | 2 | 6 | 12 | 1:4.3 | 2.79 |
| Veal chop suey | 4 | 3 | 12 | 1:5.4 | 2.22 |
| Salsbury steak | 3 | 4 | 12 | 1:6.1 | 1.97 |
| Tomato sauce | 1.5 | 6 | 9 | 1:5.4 | 1.67 |
| Creole soup | 1.5 | 6 | 9 | 1:5.4 | 1.67 |
| Minestrone soup | 2 | 4 | 8 | 1:5.4 | 1.48 |
| Navy bean soup | 2 | 4 | 8 | 1:5.4 | 1.48 |
| Smothered pork steak | 4 | 2 | 8 | 1:6.1 | 1.31 |
| Chilled potato salad | 1.5 | 5 | 7.5 | 1:4.3 | 1.74 |
| Chilean dressing | 1.5 | 5 | 7.5 | 1:4.3 | 1.74 |
| Vegetable chowder | 3 | 2 | 6 | 1:5.4 | 1.11 |
| Corned beef mulligan | 3 | 2 | 6 | 1:5.4 | 1.11 |
| Beef julienne soup | .38 | 14 | 5.3 | 1:5.4 | .98 |
| Sage dressing | 1 | 5 | 5 | 1:6.1 | .82 |
| Mulligatawny soup | .75 | 6 | 4 | 1:5.4 | .74 |
| Cream of tomato soup | 1.0 | 3 | 3 | 1:5.4 | .56 |
| Corn-O'Brien | 1.5 | 2 | 3 | 1:5.4 | .56 |
| | | Total | 862.3 | | 160.35 |

Equivalent wt ratio: $\frac{862.3}{160.35} = 1:5.38$ (raw peeled onions)

1:5.98 (raw unpeeled onions considering 10% peel loss)

## SUMMARY

Published information and recipes on the rehydration ratio and equivalent weight ratio of dehydrated sliced onions were found to be extremely varied. Experimental recipe testing established the fact that the dehydrates substitute for the fresh in three distinct ratios in practical cooking. Where the onions were to be used raw, without further cooking, the dehydrates need only to be rehydrated, and the ratio here was found to be 1:4.3. In cooked recipes where liquid was present (as in creamed onions), the equivalent weight ratio was found to be 1:5.4. In recipes such as fried onions where no water was present, the ratio was found to be 1:6.1.

From all indications, the difference in ratios was due to: (1) the loss of moisture where no aqueous liquids were present during cooking, (2) the inhibition of moisture losses where liquids were present during cooking, and (3) the differences in moisture content of fresh onions and reconstituted onions.

For logistical purposes, an average equivalent weight ratio of 1:5.38 for raw, peeled onions and 1:5.98 for raw, unpeeled onions was determined by means of a frequency of use table.

## Acknowledgment

Appreciation is expressed to Mr. B. S. MacNulty of the Food Science and Engineering Division, U. S. Naval Supply Research and Development Facility, for the experimental recipe testing in this investigation.

## LITERATURE CITED

1. Army Technical Manual TM 10-412. "Recipes," U. S. Government Printing Office.
2. Navy Food Service. A bulletin published by the Navy Subsistence Office for distribution to Navy general messes.
3. Navy Recipe Service: NAVSANDA Publication No. 7, U. S. Government Printing Office.
4. Hunt, S. M. V., and Matheson, N. A. "Comparison of yield of cooked material obtained from dehydrated fish and meats." Unpublished report by Ministry of Agriculture, United Kingdom, February 1960.
5. Tousignant, D. W. *Dehydrated Foods.* Vol I, p. 32. Dehydrated Food Industries, 1952.

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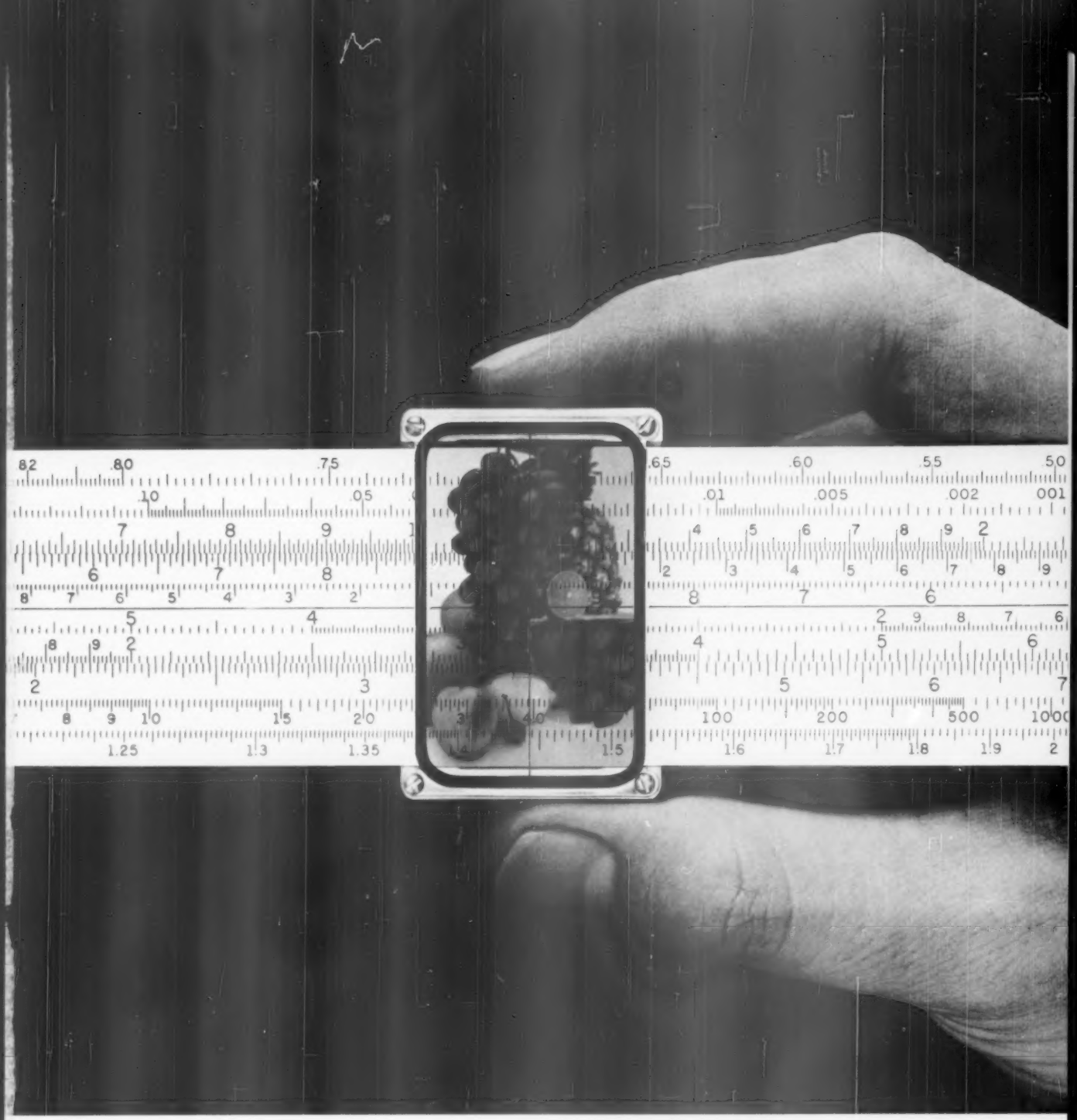

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# ABSTRACTS

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## ANALYTICAL METHODS

### Infrared analysis of carbon tetrachloride and ethanol in blood.

STEWART, R. S., ET AL. *J. Lab. Clin. Med. 56*, 148–56 (1960).

A simple, rapid method for the simultaneous identification and assay of organic chemicals in the blood has been demonstrated in the analysis of carbon tetrachloride and ethanol. The method was shown to be made quantitative for carbon tetrachloride by the use of $C^{14}$-labeled material. A significant increase in the level of carbon tetrachloride circulating in the blood was found when rabbits were exposed simultaneously to high doses of carbon tetrachloride and ethanol. An increase in the serum glutamic oxalacetic transaminase levels was also observed.

### Starch electrophoresis. III. Starch gel electrophoresis.

BLOEMENDAL, H. (Netherlands Cancer Inst., Amsterdam). *J. Chromatography 3*, 509–19 (1960).

Numerous investigations have demonstrated without doubt that—from an analytical standpoint—the starch gel technique has certain advantages over the starch column method, and even over the starch block method. For preparative purposes, however, the gel technique has up to now not been found convenient. There must be certainty that the sepd. fractions are homogeneously distributed through a cross section of the medium. In starch gel strips the sepn. is never completely homogeneous throughout the gel when the strip is sliced after the electrophoretic run. For analytical purposes this is of no importance, as only the stained surface of the strip cut horizontally is considered. In preparative work, however, the variations in different layers of the gel cause overlapping of the sepd. zones and the stained surface does not correspond with the pattern inside the strip.

### Rapid micromethods of elemental analysis. I. Determination of chlorine in organic compounds.

OLSON, E. C. AND KRIVIS, A. F. (Upjohn Co., Kalamazoo, Mich.). *Microchem. J. 4*, 181–6 (1960).

A rapid and accurate method for the detn. of chlorine in org. compds. has been developed. The sample is decomposed by a simplified Schoniger oxygen flask combustion and the liberated chloride ion is detd. by coulometric titration with electrolytically generated silver ion. The mean deviation on samples contg. 22.45 and 12.81% chlorine was ±0.085 and ±0.060%, resp. The method requires

3–5 mg. of sample and may be applied to smaller samples, when necessary, by decreasing the generation current. The procedure is rapid; an analyst can complete 20–25 samples a day with ease.

**Ultra-violet determination of citral in lemongrass oils which contain myrcene.**

FEARNS, E. C., MITCHELL, D. A. AND MITZNER, B. M. (Intern. Flavors & Fragrances Inc., Union Beach, N. J.). *Perfumery Essent. Oil Rec. 51*, 355–6 (1960).

A recent method for the detn. of citral in lemongrass oil by ultra-violet absorption was found to be inapplicable to West Indian oils because of interference from myrcene. Both citral and myrcene absorb sufficiently at 224.5 mμ and 238 mμ not to interfere with each other. It has been found possible to det. citral by measuring ultra-violet absorbances at these 2 wavelengths and applying a set of simultaneous equations.

## BIOLOGICAL SCIENCES

### Biochemistry

**Effects of diet on incorporation of acetate-1-$C^{14}$ into cholesterol by rat liver slices.**

CARROLL, K. K. (Univ. of Western Ontario, London, Can.). *Can. J. Biochem. Physiol. 38*, 649–56 (1960).

The rate of incorporation of acetate-1-$C^{14}$ into cholesterol by rat liver slices decreased when animals were transferred from a comm. chow diet to semi-synthetic diets. A greater decrease was observed when the test diet contained oleic acid or olive oil than when it contained higher homologues of oleic acid, or prepns. of cerebrosides. The decrease was not affected by the presence or absence of fat-sol. vitamins in the test diet contg. oleic acid. Amphenone B affected acetate incorporation into liver cholesterol differently depending on whether it was fed in a chow diet or a semisynthetic diet.

**Studies on the mechanism of fatty acid synthesis. VIII. The participation of protein-bound biotin in the biosynthesis of fatty acids.**

WAKIL, S. J. AND GIBSON, D. M. (Univ. of Wisconsin, Madison). *Biochim. et Biophys. Acta 41*, 122–9 (1960).

One of 2 purified enzymic components, which catalyze the synthesis of palmitate from acetyl CoA, is rich in protein-bound biotin. Avidin, the egg white protein that specifically binds biotin, severely inhibits fatty acid synthesis. Added free biotin prevents the occurrence of this avidin inhibition. These observations indicate that a biotin-contg. enzyme participates directly in fatty acid biosynthesis.

**Protein biosynthesis by a cell-free bacterial system. III. Determination of new peptide bonds; requirement for the "amino acid incorporation enzyme" in protein biosynthesis.**

BELJANSKI, M. (Inst. Pasteur, Paris, France). *Biochim. et Biophys. Acta 41*, 104–10 (1960).

The incorporation of ($C^{14}$) amino acids into protein by *Alcaligenes faecalis* fragments has been demonstrated. Using ($C^{14}$) valine, it was found that most of the incorporated amino acid was within the peptide chains. Alcaligenes fragments have been partially solubilized by treatment with perfluoro octanoate without affecting the incorporation activity. The soluble fraction obtained after this treatment can be replaced by purified "amino acid incorporation enzymes."

**The sorption of water vapor by native and denatured egg albumin.**

ALTMAN, R. L. AND BENSON, S. W. (Univ. of Southern California, Los Angeles). *J. Phys. Chem. 64*, 951–5 (1960).

The sorption-desorption cycles for water on native and on steam-, heat- and alcohol-denatured egg albumins have been studied from 25 to 70° for the first and up to 100° for the latter three. The amt. of water sorbed is a very weak function of the temp. at high relative humidity and only slightly more sensitive at low humidities. Between 70 and 100° denatured albumin shows no hysteresis above a relative humidity of 0.7. The sorption isotherms of the 3 denatured egg albumins were significantly different both at 25 and 40° indicating that denatured albumin is not a uniquely defined material.

## Microbiology

### Further serological studies of staphylococcal enterotoxin.

CASMAN, E. P. (U. S. Dept. of Health, Educ. and Welfare, Washington, D. C.). *J. Bacteriol. 79*, 849–56 (1960).

Using antienterotoxic sera prepd. by injecting rabbits with enterotoxin produced by staphylococcus strains 196E, S6, and 243, a specific serological test for 2 antigens assocd. with heat-resistant enterotoxicity was developed. The two antigens were tentatively designated as types "E" and "F". Whereas, most of the strains isolated from cases of enteritis produced both types "E" and "F" antigens, only type "F" was formed by strains isolated from foods implicated in food poisoning incidents.

## Nutrition

### Effect of dietary oils on the depletion of vitamin A.

MURRAY, T. K., BEARE, J. L. AND CAMPBELL, J. A. (Food and Drug Labs., Dept. of Natl. Health and Welfare, Ottawa, Can.). *Can. J. Biochem. Physiol. 38*, 663–6 (1960).

The effect of dietary corn oil, olive oil, and rapeseed oil on the vitamin A content of liver and kidney during depletion of the vitamin was studied. Dietary oil had no influence on the rate at which liver stores of the vitamin declined in a 2 month period.

### Effect on serum cholesterol levels of replacing milk fat by soya bean oil.

ANONYMOUS. *Nutrition Revs. 18*, 205–6 (1960).

The serum cholesterol level in a series of mental patients in Finland was reduced by replacing butterfat with an emulsified soya bean oil and using a more unsatd. margarine in the diet. The study has not yet proceeded long enough to det. if there is any influence on the frequency of coronary artery disease and other atherosclerotic manifestations along with the decrease in cholesterol level.

### Effect of lipotropic agents upon the net synthesis of cholesterol in the rat.

MOOKERJEA, S. AND LUCAS, C. C. (Univ. of Toronto, Can.). *Can. J. Biochem. Physiol. 38*, 757–61 (1960).

The content of cholesterol in the bodies of young male rats fed a basal hypolipotropic diet has been compared with that of other rats pair-fed on similar diets supplemented with choline chloride, methionine, or vitamin $B_{12}$, resp. Increased efficiency of utilization of the food and variable lipotropic effects were observed, but no significant difference was found in the total amts. of cholesterol at the end of the 3-week test periods. The lipotropic agents do not influence to any significant degree the net biosynthesis of cholesterol in rats fed this type of diet but they do affect the distribution, tending to keep the liver lipids, including cholesterol, in the normal range.

### The protein requirement of the growing chick determined with amino acid mixtures.

KLAIN, G. J., ET AL. (Univ. of Illinois, Urbana). *J. Nutrition 71*, 209–12 (1960).

The nitrogen requirement of chicks was detd. using cryst. amino acid diets. For optimum efficiency of feed utilization the requirement was found to be approximately 4.0% nitrogen. It was observed, however, that a lower nitrogen level (3.2%) resulted in equally good growth and nitrogen retention, but lower feed utilization. Chicks were able to gain satisfactorily on this low nitrogen diet by voluntarily eating more of the ration.

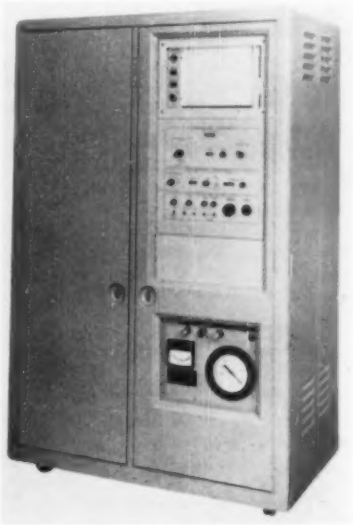
### D-Amino acids as source of non- specific nitrogen for growth of rats.

RECHCIGL, M., LOOSLI, J. K. AND WILLIAMS, H. H. (Cornell Univ., Ithaca, N. Y.). *Proc. Soc. Exptl. Biol. Med. 104*, 448–52 (1960).

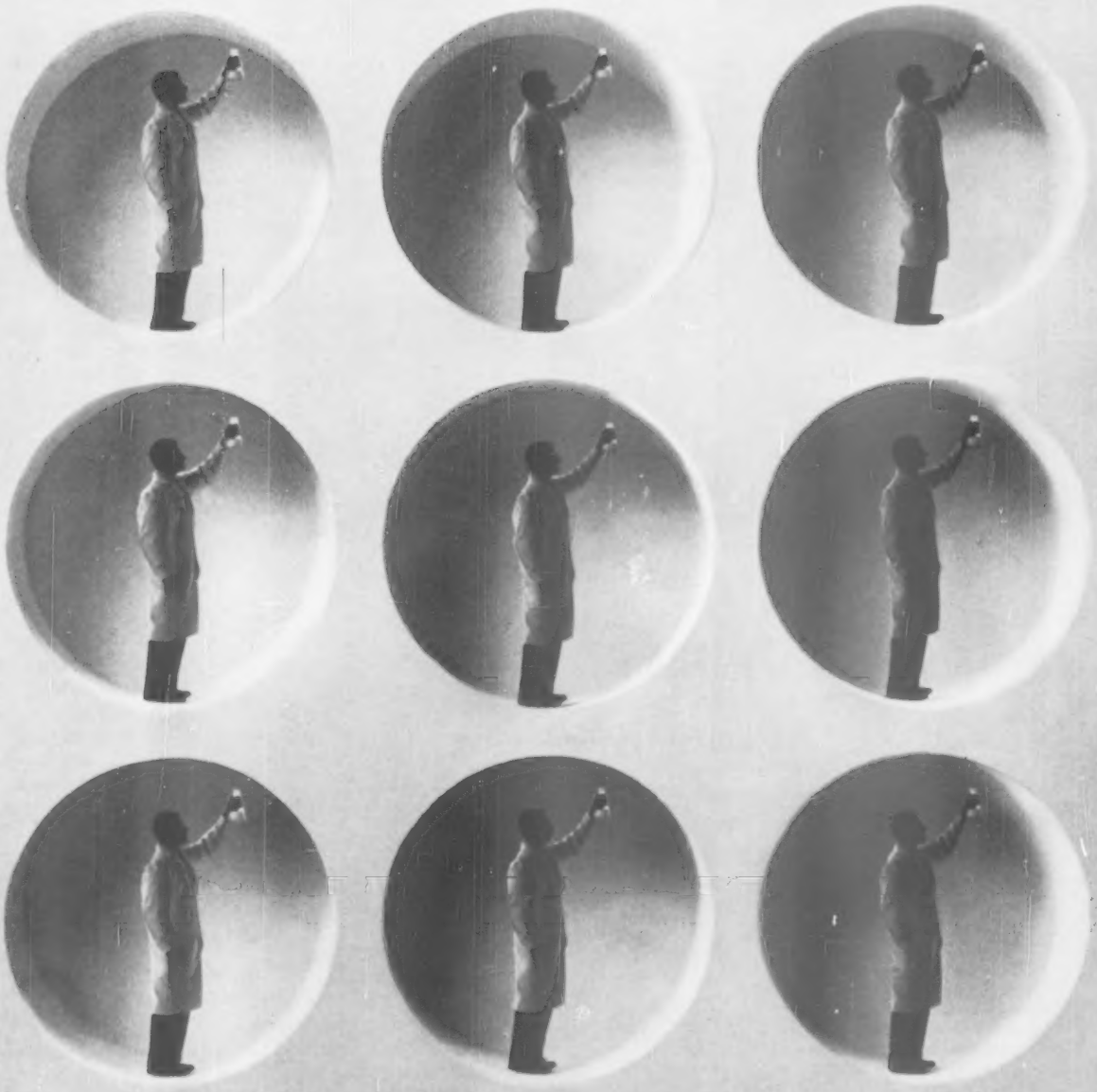
Rats fed a diet contg. physiol. amts. of essential L-amino acids but lacking non-essential amino acids grew at a slow rate. Growth rate was increased by increasing concn. of all essential amino acids. Feeding a mixt. of DL-amino acids in comparable amts. resulted in growth retardation of animals. Growth inhibition produced by the racemic mixt. was traced to an isoleucine deficiency resulting from inclusion of DL-isoleucine, which was actually a mixt. of all 4 isomers, thus effectively diluting the active isomer. Substitution of L-isoleucine or a mixt. of L- and D-allo-isoleucine for the racemic compd. in the DL mixt. entirely overcame inhibition and produced growth comparable to that obtained with L-amino acids. The expts. provide evidence that D-amino acids can be effectively used as a source of nitrogen for biosynthesis of non-essential amino acids.

## EQUIPMENT

A newly-introduced automatic recording thermobalance has been designed to perform thermogravimetric studies in vacuum or controlled atmospheres at temperatures to 1000° C. Called the Thermo-Grav, it measures and automatically records changes in weight as a function of temperature programmed for a selected linear heating rate, or as a function of time at a constant temperature. Among the reactions said to be obtainable for study are absorption, adsorption and desorption, as well as vaporization, sublimation, dehydration, thermal decomposition of inorganic and organic salts, degradation of organic and organometallic compounds, polymers, and related types of thermal decomposition. Bulletin 2328 and Reprint No. 119 describe the Thermo-Grav in detail and are free upon request from the American Instrument Co., Inc., 8030 Georgia Avenue, Silver Spring, Maryland.



A new micro-pressurometer has been developed for the study of pressure required to break individual cell walls of food products in raw, dehydrated and frozen states. The instrument breaks individual cells with a glass rod and pressure is measured on a gram scale wheel. Cell is visible during



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ATI Aseptic-Thermo Indicator Company

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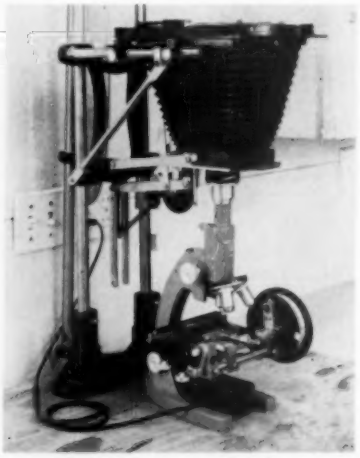
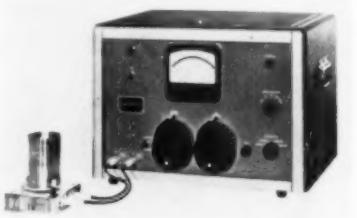
breaking and may also be micro-photographed. In addition, the operator is able to roll the individual cell prior to breaking. Studies with the micro-pressurometer are being used to design food processing equipment and techniques for Lamb-Weston, Inc., Weston, Oregon, from whom further information may be obtained.



**Side view of Lamb-Weston Micro-pressurometer with photographic setup to picture cell breakage appearance when pressure is applied by turning gram measuring wheel on right of view plate.**

A new industrial moisture analyzer designed for process or quality control systems has recently been announced by the



Boonton Polytechnic Company, Inc. The method of moisture determination is by means of radio frequency power absorption. According to Boonton, their moisture analyzer, which may be used "in stream" or in "batch" sampling, provides higher quality control, faster production, lower operating and manufacturing costs, and a uniformly high quality finished product. Features claimed by Boonton for their Model HFR-4E are moisture content range of 0-80%; accuracy of 0.001-0.5%; instantaneous tests; does not chemically or physically change material; is not affected by density of material, granule size, moisture gradient, or process temperature; precludes erroneous measurements due to capacitance; and measures moisture in solids, liquids, sheets, granules, pastes, chips, powders, shreds, and boards. For further information, contact Boonton Polytechnic Co., Inc., Department 146, P. O. Box 125, Boonton, N. J.

## COMMENT

An improved method for detecting the elusive microorganisms responsible for food spoilage and, possibly, food poisoning outbreaks will be sought by **John E. Despaul**, of the Armed Forces Military Subsistenee Testing Laboratory, 1819 West Pershing Road, who was recently awarded a Secretary of the Army's Research and Study Fellowship. Mr. Despaul will undertake graduate study and research at the University of Kentucky, Lexington, at Cambridge University, England, and at the Central Public Health Laboratory in London. His graduate studies began September 26 at the University of Kentucky. At the University of Kentucky, working under Dr. Ralph H. Weaver, Despaul will seek to improve procedures for isolating *Clostridium perfringens* from foods. At the Central Public Health Laboratory, London, in June 1961, he will study under Dr. Betty C. Hobbs and after that at the Low Temperature Research Station in Cambridge with Dr. M. Ingram.

**J. E. Despaul**

# MORE THAN A SUBSTITUTE

## HERE'S ONE THAT'S BOTH FISH and FOWL

Here's an ingredient that gives you *everything* in the way of clearer, cleaner, better flavor for fowl and sea food products – new Maggi's Hydrolyzed Plant Protein 3H-3.

A *basic* flavor, always uniform, unaffected by processing and unusually economical, Maggi's 3H-3 never varies in taste or quality, has been proved by leading processors.

Like the entire Maggi's Hydrolyzed Plant Protein series – for beef, veal and pork, too – 3H-3 makes a marked contribution to the desired flavor without adding other flavor characteristics.

The technologists who developed these unique Maggi's Hydrolyzed Plant Proteins are available to assist you in your formulations. Write for free samples and data.

**FOR VEAL and PORK**

Maggi's Hydrolyzed Plant Protein 3-H1 is designed particularly for use in veal and pork products. Clear and clean as well, it provides a medium-strength meaty background and is light in color.

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FLEXIBLE FOR LABS — RUGGED FOR PRODUCTION

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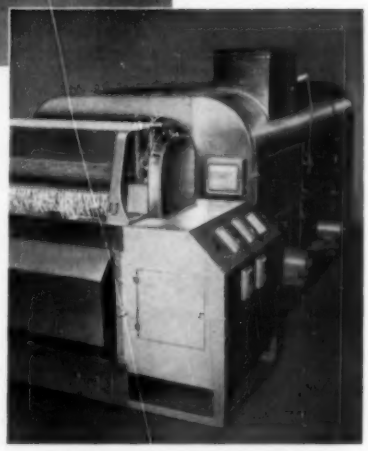

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SARGENT'S small to medium size dryers are outstanding examples of the sound economy of "designing and building the machine for the job" in the food industry. These flexible, rugged machines may consist of but two or three drying sections and a feeder (vibrating or standard) — or where required, multiple drying sections plus baking, curing and cooling sections — all in one compact, space-saving, economical machine.

Engineered specifically for pilot plant or moderate volume production, they are easily enlarged by simply adding more drying sections and, where desired, extruders, granulators — even a blow-up section to "fluff" products such as dry breakfast foods during drying.

Because they are designed and built by SARGENT, these rugged moderate-size workers can be depended upon to do a he-man size job on food products and by-products — from milk curd to sliced apples, from cereals to fruits and nuts and coffee.

As with all SARGENT equipment, these new-size dryers are the speediest to erect, the easiest and most economical to clean-out and to maintain of any on the market. Performance is unconditionally guaranteed by us.

Write us your product-drying requirements and let us give you details.

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## PERSONNEL

The Snow Flake Canning Co., Brunswick, Maine, has announced that **Colonel Robert F. Carter,** Sales Manager of the Frozen Foods Division, and **Francis R. Saunders,** General Production Manager, were elected to the Board of Directors on September 7th.

Colonel Carter, born in Mahanoy City, Pennsylvania, in 1899, graduated from West Point in November 1918, and served in the regular army for 28 years. In Washington during the early part of World War II he was instrumental in organizing the processed foods procurement system for the Armed Forces and for lend lease which operated so efficiently throughout the war. Francis R. Saunders, born in Gloucester, Massachusetts, in 1918, became interested in food processing at a very early age. In 1940 he graduated from the University of Massachusetts, where he majored in Chemistry and Food Technology.

**Dr. Eugene N. Bilenker** has recently joined the Research Quality Control Group at Thomas J. Lipton, Inc., Hoboken, New Jersey. He was formerly associated with the Maxwell House Coffee Division of General Food's Research Department, where he worked on new process development. Dr. Bilenker earned a B.A. degree from Brooklyn College, and also holds an M.S. degree in Dairy Manufacture from the University of Connecticut, and a Ph.D. in Food Technology from Massachusetts Institute of Technology.

**Dr. H. E. Robinson,** Chicago Section Chairman and vice president in charge of the research laboratories, engineering research and equipment development, Swift & Company, has assumed direction of a number of products-for-industry operations. Departments now under Dr. Robinson, in addition to general and engineering research, include adhesives, gelatin, stabilizers, soap and chemicals and the Technical Products Plant at Hammond, Indiana. Dr. Robinson joined the Swift research staff in

1932, became an assistant director of research in 1941, assistant director of laboratories in 1950, director of laboratories in 1953 and was elected vice president in 1959.

**Eugene Misiaszek** has been named project leader in the Jell-O division laboratory of the General Foods Research Center at Tarrytown, N. Y. He joined General Foods in 1955 as an assistant technologist in the packaging research laboratory, becoming an associate technologist in the Jell-O laboratory in 1957. Mr. Misiaszek is a graduate of the University of Massachusetts where he received his Master of Science Degree in Food Technology.

**Dr. Hugo Eryk Wistreich** has been appointed Director of Research and Development for Preservaline Mfg. Co., Flemington, New Jersey. Dr. Wistreich assumed his new post September 1st and is now located at the Company's offices and plant in Flemington, New Jersey. He was formerly Research Director for the Reliable Packing Company, Chicago, Illinois. Dr. Wistreich, born in Jasto, Poland, received his early education in the secondary schools and universities of that country and in France. He completed his education at Rutgers University, where he was awarded Master of Science and Doctorate degrees in the fields of Food Technology and Food Science.

**Dr. Robert W. Haman** has been appointed General Manager of the Minnesota Malting Company of Cannon Falls, Minnesota. In his new duties, he not only will have over-all responsibility of plant operations, but also quality control and research. Dr. Haman, who has spent over twenty years in quality control and research, attended the University of Wisconsin, where he did his undergraduate and graduate work, serving on the faculty for two years after receiving his doctorate.

**J. P. Pfaff** recently assumed full District Manager responsibilities for all of Hercules Powder Company, Virginia Cellulose Department products in the Chicago area. Mr. Pfaff joined Huron Milling Division in 1946 as a salesman, and became District Manager of the Chicago Huron products office in 1957. In another Chicago change, **Mr. J. L. Lawes** has been named District Sales Supervisor. He joined Hercules upon graduation from Cornell University with a B.Ch.E. in 1950, and worked in various capacities in Hopewell, Va., San Francisco, and Los Angeles since that time.

**Gavin Lee Hansen** has joined the expanding Technical Staff of Paul-Lewis Laboratories, Inc., of Milwaukee, Wisconsin. He will serve in the Bacteriology Department under the direction of Dr. Paul K. Steinke. Mr. Hansen is a 1960 graduate of the College of Agriculture, University of Wisconsin in Madison, Wisconsin.


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4. Conduct research on new ideas suggested by you.

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**Thomas A. Bruce,** Charter Professional Member of the IFT, has been appointed Assistant Western Regional Manager of the Industrial Division, Corn Products Sales Company. A graduate of Bradley University, Mr. Bruce has been associated with Corn Products for over forty years, and for the past several years has been located in New York.

T. A. Bruce

Merck & Co., Inc., announces the appointment of **Robert P. Dudley** to the newly created position of Meat Products Manager in the General Products Department. In this position, he will be responsible for the marketing functions of planning and coordinating the growth of Merck's present products for the meat industry. Dudley joined the company in 1947 as a microbiologist in Process Development and four years ago, he was promoted to the position of Meat Products Specialist in the Chemical Division Product Development group. He was recipient of one of four individual 1960 Food Technology Industrial Achievement Awards for his part in scaling the American Meat Institute Foundation's laboratory process to control the fermentation of various meat products up to factory production levels and solving the problems of packaging, stability and distribution.

**L. Robert Strong** has recently been appointed technical director of Diamond Crystal Salt Co. He was previously responsible for production supervision and quality control at Kroger Company in Cincinnati, Ohio, and prior to that spent a year and a half at the Food and Container Institute as a member of the Army Quartermaster Corps and a like tenure at American Can Co., Maywood, Ill. In his new position, Mr. Strong will be part of a sales team whose efforts cover baking, canning, confectionery, dairy, feed mixing, meat packing, milling, tanning, textile, water conditioning and other industrial fields. A native of Grand Rapids, Mich., he graduated from Michigan State University in 1952 and received his master's degree in food technology a year later.

L. R. Strong

**Dr. Sidney D. Upham** has recently joined Marine Colloids, Inc., as Vice President and Research Director. Dr. Upham holds an A.B. in Chemistry from Clark University and a Ph.D. in Organic Chemistry from Oklahoma State University. For the past 20 years he has been associated with American Cyanamid Company, the last five as Director of Product Research Laboratories, Agricultural Division.

S. D. Upham

## *Give yourself this quick quiz on ST. JOHN'S BREAD*

**St. John's Bread is the dried, bean-like pod of the evergreen Carob tree, native to the Mediterranean area. It has been known to and used by mankind for thousands of years. Cyprus alone produces as much as 100,000 tons in a single harvest.**

**Q.** *Is St. John's Bread used as a food, a medicine or a flavor?*

**A.** All three. As a medicine, Carob flour alleviates diarrhea, retards vomiting in infants, and brings some relief in coughing and nasal congestion caused by the common cold. It is also helpful as a mild laxative and diuretic. As a food, St. John's Bread is high in sugar and proteins. Europeans have fed it to cattle for years, and today it is being used more and more as a substitute for coffee, chocolate and cocoa, as well as in beverages resembling malted milk. As flavoring, it is used in manufactured desserts, cakes, cookies, candy, ice cream, dressing, pie fillings and the like. In syrup form, it is used by the tobacco industry as a flavoring agent for chewing and pipe tobacco.

**Q.** *In what forms is St. John's Bread used?*

**A.** Besides the flour and syrup mentioned above, St. John's Bread is consumed and administered medicinally in the form of elixirs, tea mixtures, pills, whole pods and in powder.

**Q.** *What are the specifications of St. John's Bread?*

**A.** Natural (unroasted) St. John's Bread contains lignin, hemicellulose, pectine, proteins, and a variety of sugars (40-50%.) Water content is 10%. It also has a fractional percentage of isobutyric acid, which has a rather unpleasant odor. Roasting gets rid of this odor, and darkens the color. When macerated in water, roasted St. John's Bread powder turns a yellowish brown.

**Q.** *What is the consumption of St. John's Bread in the U. S.?*

**A.** From 1,500 to 2,500 tons annually.

**Q.** *How is St. John's Bread commercially available?*

**A.** Meer Corporation offers St. John's Bread in eight different forms, six natural (unroasted) and two roasted. *Whole pods* are available in Extra Select grade in original 56-lb. cases, and in standard grade in 110-lb. burlap bags. St. John's Bread, ground for percolation to mesh 4, is supplied in 200-lb. burlap bags; and powdered to mesh 60, in 200-lb. fibre drums. Kibbled (without seeds), it is available in 150-lb. burlap bags. S. E. St. John's Bread, "Meer FR", a standardized flavor extract, comes in 50- and 100-lb. resin-lined steel pails. The roasted forms include mesh 4, ground for percolation, in 200-lb. fibre drums.

For detailed information, including botanical origin, action and uses, pharmacognosy and chemistry, and dosage and administration, write us for a free copy of the bulletin, St. John's Bread.

**Q.** *What other Botanicals does Meer process?*

**A.** Practically every botanical known and used by man. Additional members of the Meer product line include gum, drug extracts, and other products. Whatever *your* needs, you'll appreciate our painstaking quality control and our personalized service.

***Data on St. John's Bread, including assay procedure, is available on request.***

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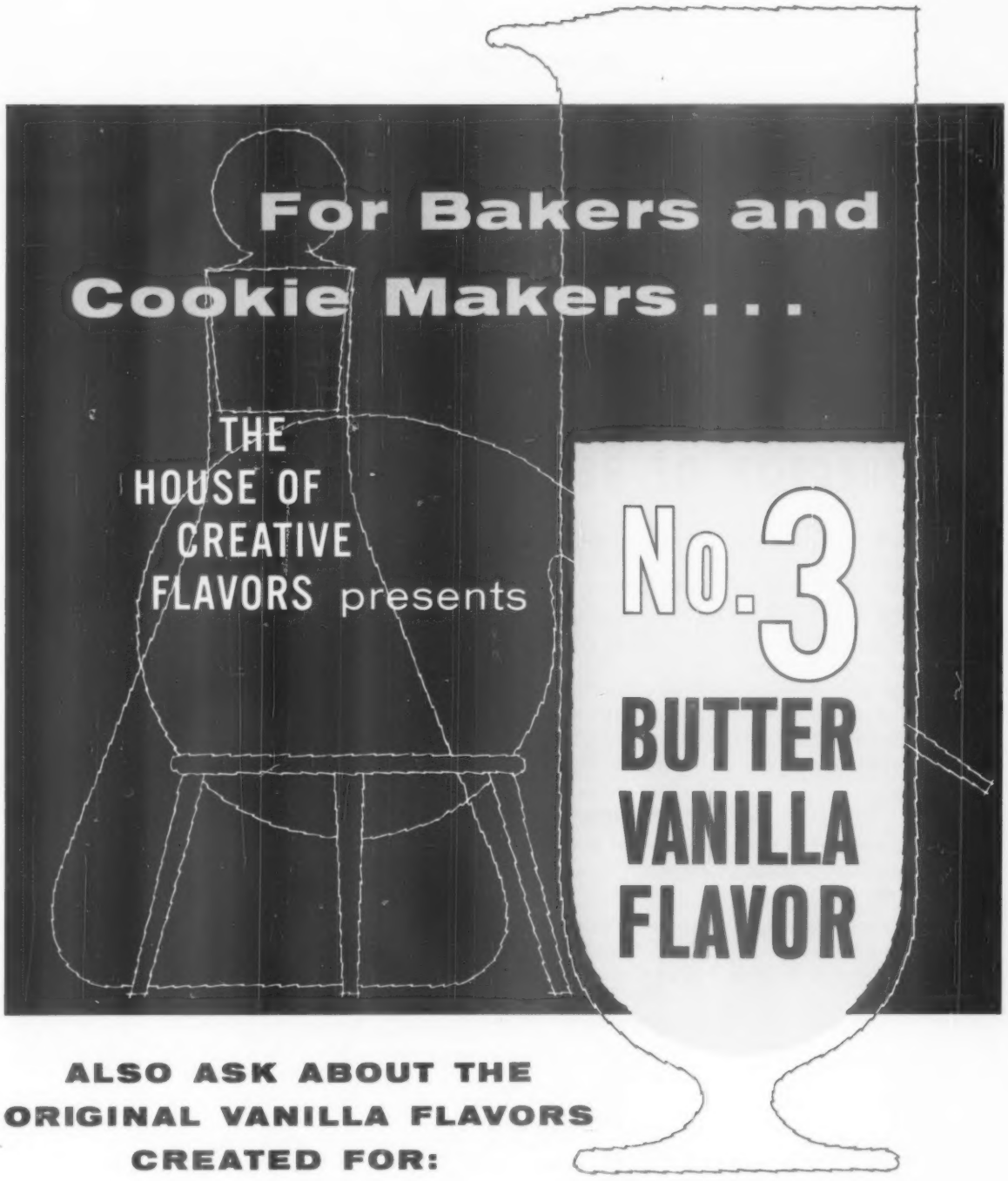


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ROCHESTER, N. Y.

The Norda Essential Oil and Chemical Company, Inc. announces the appointment of **Leo J. Amorosi** as Director of The Essential Oil and Aromatic Divisions. Mr. Amorosi, a native New Yorker, joined Norda in 1944.

L. J. Amorosi

**EXPANSION NEWS**

Mr. F. W. Griffith, Executive Vice President of The Griffith Laboratories, Inc., has announced that Griffith has purchased Relco Specialties, Inc., manufacturer of bakery specialties, all the way from macaroon crunch to flavors and emulsions. Located at 855 Rahway Ave., Union, N. J., it is one of the most modern food industry plants in the East.


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Minimum of 5 years experience as Director of Research with a business or research organization or in a large organization as the Assistant Director of the Research Department.

Graduate work from a university or college of recognized standing (or the equivalent) with major study in Food Technology, Chemical Engineering or related fields.

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### PHYSICAL CHEMIST, Ph.D.

**A recent graduate or a man with a few years' experience. Opportunity for growth to a top research job in this leading Food Company.**

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**Real challenging opportunity for growth. Prefer a recent graduate or a young man with a few years' experience.**

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FOOD TECHNOLOGIST

Medium size food processing company in Western New York has opening for Food Technologist in product/process research and development. B.S. or M.S. level degree. Salary according to training and experience. Excellent fringe benefit program. Send detailed resumé to: BOX 814.

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FOOD TECHNOLOGISTS

B.S. and Ph.D. openings for NUTRITIONAL PRODUCT DEVELOPMENT. Food or Dairy Technologists, Food or Dairy Chemists, or Food Engineers for the development of product formulations to meet nutritional, taste, texture, and appearance requirements.

0–8 years' experience. New research positions with rapidly growing manufacturer of nutritional and pharmaceutical products.

Liberal employee benefits, and relocation allowances. Please send resumé and salary requirements to:

Technical Employment Manager
Mead Johnson & Company
Evansville 21, Indiana

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Research food technologist. Eastern location. 1–5 years experience with fats, oils, and emulsions. B.S. or M.S. required, to develop new products in oil emulsions and salad dressings. REPLY BOX P-638.

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WANTED: Experienced pickle man to assume responsibility for quality control and serve as Assistant Plant Manager. Southeastern location. Established company. Reply should include education, age, experience and present salary. REPLY BOX 817.

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AVAILABLE: Ph.D. Food Technology, 1953; M.S. Food Tech., B.S. Dairy Bacteriology. Married—Age 37. Have worked in antibiotic research, frozen food production, Ag. Expt. Sta. research, and Technical Service to the canning industry. REPLY BOX 816.

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AVAILABLE: FLAVOR CHEMIST—15 yrs. experience in essential oils, flavors and extracts for the Beverage, Baking, Candy, Ice Cream and Liquor Industries. Diversified experience—research, development, production, quality control and customer service. Metropolitan New York Area preferred. REPLY BOX 812.

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Flavor chemist. Midwest location. Ability to create and duplicate flavors most important for experienced person, preferably with degree. REPLY BOX P-603.

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Senior flavor chemist. East coast location. Ten years experience and B.S. in chemistry or equivalent, to create and improve flavor compounds in the essential oil field. REPLY BOX P-604.

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Flavor chemist. East coast location. Four years experience and B.S. in chemistry or equivalent, to create and improve flavor compounds in the essential oil field. REPLY BOX P-605.

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Food technologist. Eastern location. B.S. degree and no experience required, to conduct research investigations for product development. REPLY BOX P-606.

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Chemist. Western location. College graduate in chemistry with basic cereal grain experience, for evaluation, production control and final malt evaluation. Family man desired. Promotion to chief chemist possible. REPLY BOX P-610.

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TECHNICAL OPPORTUNITIES

Expanding product line and plant expansion has created a need for additional top level Research and Engineering personnel in Research and Development and Staff Engineering activities in Minneapolis.

*Technical Manager—Product Development*

Basic responsibility for Research and Development techniques in the formulation of new products and improvement of current products. Ph.D. or Masters degree in Chemistry, Food Technology or related science is required. Research experience necessary. Experience in foods preferred.

*Process Engineer*

Provide engineering administration for food process equipment installations including preparation of capital appropriations requests, requisitions, control of budgeted funds and supervision of installation, design and drafting. Chemical Engineering graduate with control and instrumentation experience preferred. Five years experience desired. Food industry experience preferred. Contact:

Cal Butler
THE PILLSBURY COMPANY
Minneapolis 2, Minnesota

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Food technologist. Midwest location. B.S. in food technology or chemistry with 5–8 years experience. Considerable travel to assist customers with product applications. REPLY BOX P-633.

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Development engineer. Northeastern location. B.S. with 3–5 years experience in food or chemical processing, particularly laboratory and pilot plant operation, to lead pilot plant equipment studies solely in new development. REPLY BOX P-634.

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Food technician. Southwestern location. Food technology graduate or experience in cannery laboratory required, to do quality control work. REPLY BOX P-635.

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Senior technologist. Eastern location. Experienced analytical chemist with B.S. or M.S. in chemistry and some bacteriology, to be in charge of laboratory services engaged in chemical and microphysical analysis of food products and ingredients. REPLY BOX P-636.

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Packaging technologist. West coast location. Film experience and B.S. in related field, to develop new packaging. Some travel. REPLY BOX P-637.

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Chemist. Midwest location. B.S. in chemistry with 2–5 years industrial laboratory experience. Varied chemical work, particularly analytical chemistry. Research and production involved. REPLY BOX P-640.

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Flavor chemist. Midwest location. Experienced compounder to aid in flavor development and production. Organoleptic acuity essential. REPLY BOX P-641.

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Food technologist. Western location. B.S. in food technology or chemistry, to develop new product formulae and processes, analyze raw materials, and other varied duties. REPLY BOX P-650.

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Jr. technologist. Eastern location. Bachelor's degree and no experience required for performing laboratory experiments and instructing others in routine lab work. REPLY BOX P-653.

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Assistant technologist. Eastern location. B.S. and 2–3 years experience, to conduct advanced laboratory experiments on pilot plant development. REPLY BOX P-654.

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Food technologist. Eastern location. B.S. in food technology or chemistry with 0–2 years experience in meat, cereal and baking, or canning, to develop applications of products to the food industry. REPLY BOX P-656.

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Technical service representative. Midwest, south, or eastern location. B.S. with experience in packaging, processing, or customer service, to provide technical service to users of compressed gases. REPLY BOX P-661.

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Research chemical engineer. Midwest location. B.S. in chemical engineering, to conduct pilot plant product and process development studies. REPLY BOX P-664.

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Food technologist, bakery products. East coast location. B.S. in food technology or allied science and 2 years experience, to aid in product development of prepared mixes. REPLY BOX P-668.

## SITUATIONS WANTED

**Unless otherwise specified, particulars on the following individuals may be obtained by writing: Executive Secretary, Institute of Food Technologists, 176 West Adams Street, Chicago 3, Illinois. Request by box number.**

Food technologist or lab technical position dealing with juices or cereal products desired by graduate with major in agricultural chemistry. REPLY BOX A-1.

1950 graduate with B.S. in food technology desires position in product development, production, technical sales, technical service, packaging, or quality control. Salary, $8,000. REPLY BOX A-2.

Recent graduate with B.S. in food processing desires R&D position working with fruits or vegetables. Product development, production, or industry research preferred. Salary, $6,500. REPLY BOX A-5.

Experienced man desires quality control, product development, or production position in the area of vegetables and fruits. Salary, $12,500. REPLY BOX A-8.

1954 food technology graduate interested in quality control, research, or production management position. Interest range also covers technical service and packaging. Salary, $9,000. REPLY BOX A-14.

Young food technology graduate interested in either technical sales position, or product development or technical service oriented toward management. Product preference is fruit and vegetables. Salary, $6,800. REPLY BOX A-17.

Meats, fats and oils, and feed interest man who desires position as food chemist or food technologist. Salary, $7,500. REPLY BOX A-20.

1956 graduate with B.Sc. in Home Economics indicates she is interested in a product development or food promotion position. Salary, $6,200. REPLY BOX A-25.

W. W. II veteran with five years experience in packaging seeking position in that field, purchasing, or engineering. Product preference is frozen foods. Salary, $9,000. REPLY BOX A-28.

Quality control position with primary emphasis on frozen foods desired by 1955 food technology graduate. Salary, $5,800. REPLY BOX A-30.

Cereal chemist graduate desires executive technical or managerial position. Interests are product development, production, technical service, packaging, and quality control. Salary, $20,000. REPLY BOX A-37.

Young food technology graduate desires technical sales and service position in the food industry. REPLY BOX A-40.

Technical service in the dairy and meat industry interests young food technology graduate. Also interested in food inspection. Salary, $6,500. REPLY BOX A-43.

Experienced chemistry graduate desires position working with dairy products or cookies. Her position preference is product development, industry research, and quality control. Salary, $8,000. REPLY BOX A-44.

Young man desires position as food technologist in the fields of product development, production, technical service or quality control. Salary $7,500. REPLY BOX A-47.

Executive position in the beverage, baked goods or dairy field desired by man experienced in those industries. Salary $18,000. REPLY BOX A-50.

Industrial research, product development or quality control work with fruits and vegetables interests recent food technology graduate. Salary, $6,000. REPLY BOX A-52.

Chemistry graduate with experience in fruit concentrates and drinks desires production, technical sales, technical service or quality control position. Salary, $13,000. REPLY BOX A-54.

Plant management position concerned with production, technical sales or technical service desired by individual with promotional experience. Salary, $10,000. REPLY BOX A-58.

W. W. II veteran desires product development or packaging development position, preferably working with beverages. Salary, $9,000. REPLY BOX A-60.

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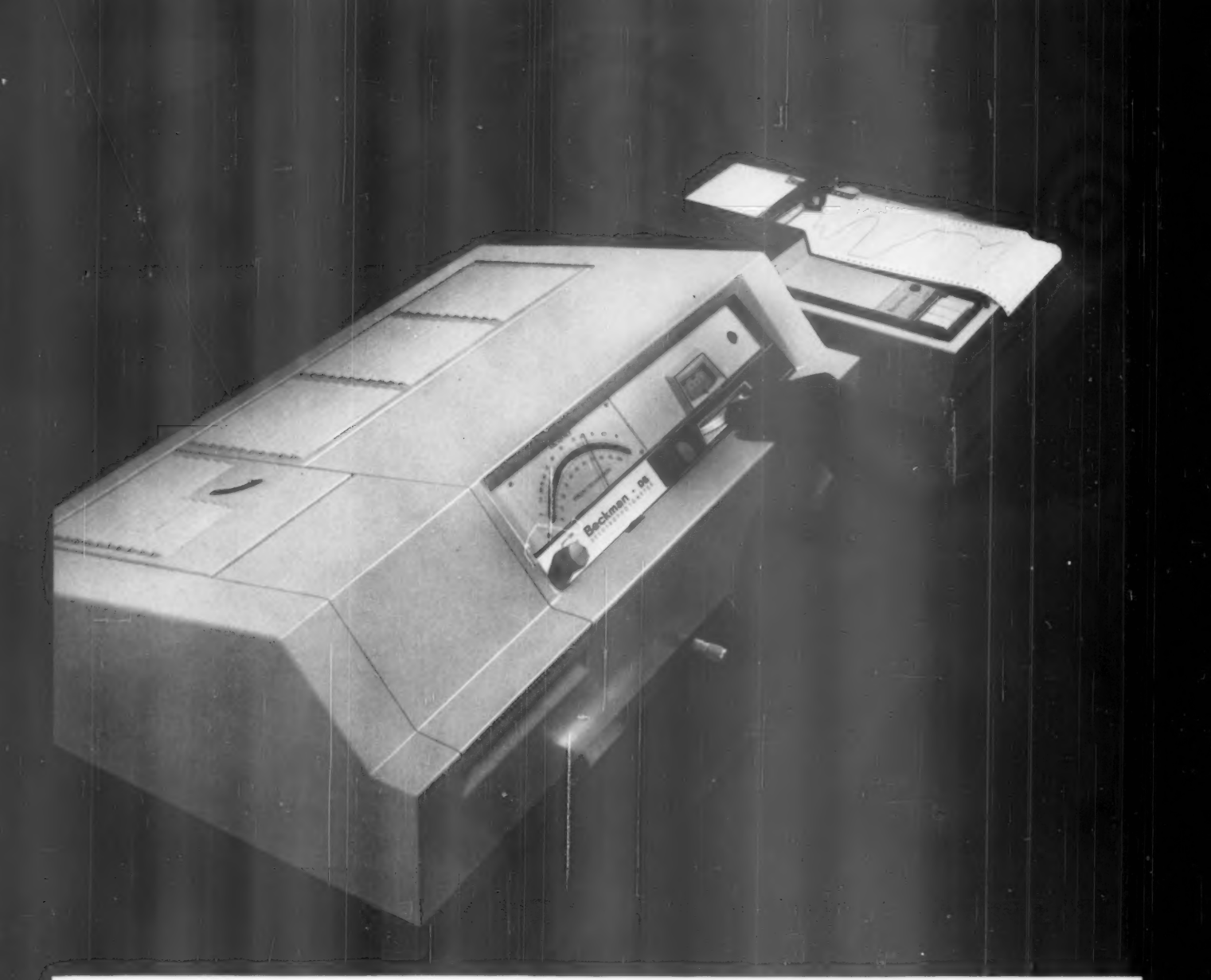


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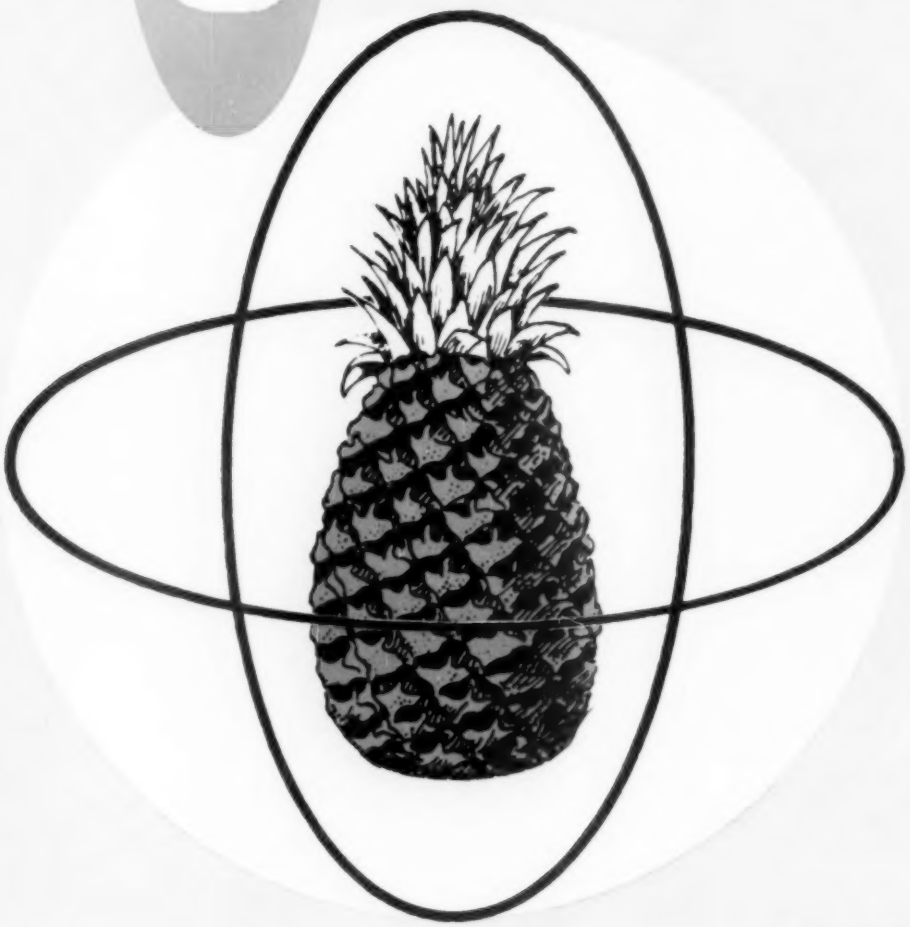

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